SUPERSONIC AIR TRANSPORTS

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SUPERSONIC AIR TRANSPORTS

TUESDAY, MAY 17, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SPECIAL INVESTIGATING SUBCOMMITTEE,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The subcommittee will come to order.

This morning we are beginning a series of hearings which will concern themselves with the development of supersonic air transportation. Worldwide tensions and farflung commercial interests of this country warn us that we must not delay such a program. At this hour international tensions are greater than at any time within recent years. In almost all of the six continents of the world flareups in the form of insurrections and riots and revolts threaten the peace of the world. Communism struts onward with a pace that mimics nazism.

In addition to this, within the last 10 years our country has made worldwide commitments guaranteeing the integrity of nations and the peace of the world.

No one here this morning can say with confidence where the events of tomorrow will demand American influence, American prestige, and, in fact, military support.

Our foreign bases are located in many parts of the world. In addition to this fact, American industry is building plants in distant lands and among strange people. America's vaunted mass production program is now well known to many nations. Our commercial interests encircle the globe and require quick and urgent means of transportation.

Recently a subcommittee of the House Armed Services Committee investigated the failure to give proper attention to intercontinental air transports, and brought out these failures in a glaring manner. It is well known that a number of nations in the world today are working on the development of a swift intercontinental transport capable of maintaining transportation to any part of the globe within a few hours. All signs warn us that we have delayed too long in launching such a program.

It is therefore timely, I think, that we begin the hearing this morning with the recommendations of outstanding authorities on our transport needs to this committee and to the U.S. Congress. In that connection, the first witness we have this morning is Mr. Ira Abbott, Director of Advanced Research Programs with NASA.

Mr. Abbott, we will be pleased to hear your statement.

STATEMENT OF IRA H. ABBOTT, DIRECTOR OF ADVANCED RESEARCH PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. ABBOTT. Thank you, Mr. Chairman.

I am grateful for this opportunity to testify before this committee and to discuss with you the problem of the supersonic transport. We in NASA are deeply interested in the possibilities of the supersonic transport; we are aware of the advantages this country would derive from its development, and have, in fact, already conducted the research that indicates its technical feasibility in the near future.

As you are well aware, the NASA retains, under its enabling legislation, the duties and responsibilities of its predecessor organization, the National Advisory Committee for Aeronautics. The primary duty of the NACA was the conduct of scientific research in the field of aeronautics. In this area the NASA continues to function in the same manner as the former NACA.

We conduct scientific research to guide and support the aeronautical activities of the Nation, both military and civilian. In this research, we cooperate closely with other governmental agencies concerned with aeronautics and with the manufacturing and air transport industries. Our activities vary from fundamental through applied research to specific testing associated with the design and development of specific aircraft. We do not design or develop aircraft, but we cooperate closely on technical matters with those who do and with those who buy and operate the aircraft, whether they be the military services or civil airlines. In fulfillment of NASA's duties in the field of aeronautics, our current research programs deal with problems of vertical takeoff and landing, steep takeoff and landing, aircraft, advanced bombers and fighters for the military services, and supersonic cruise transports.

New aircraft are thus brought about in this country by a team effort including NASA as the primary research agency, the aircraft industry with their superb design staffs and manufacturing capabilities, and the customers, whether they be military or civil, with their unique knowledge of operational requirements. This system has worked well for over 40 years. It gained and maintained American preeminence in the air.

All members of this team face special problems in the supersonic transport aside from the technical ones which I shall discuss later. One of the most serious problems is that of financing the development of such an aircraft. Historically, large performance advances in transport airplanes have been based on the results of NACA research, and have been preceded by military aircraft and engine developments which have produced the needed technology. The current subsonic jet transports provide a good example in that they were preceded by large jet bombers and tankers. These advances thus were assisted and made possible by Government-financed advances in technology. Even so, these recent developments have involved very large investments by the companies concerned.

The future supersonic transport will also benefit from NASA research and from the technology and experience generated by the USAF B–70 project. However, the step from the supersonic bomber

to the transport is greater than has previously been the case, the development costs will be much higher, and the large carrying capacity of such airplanes may well result in a smaller production for the aircraft industry.

We in NASA are not experts in economics. We feel, however, that just as private industry needs governmental assistance to finance such projects as large ocean liners and nuclear power reactors, it will also need some form of direct assistance to develop the supersonic transport. I am convinced that this country should undertake the development of the supersonic transport even though this requires Government financial assistance.

I would now like to turn to the technical situation regarding the supersonic transport. We in NASA have been interested in the supersonic transport since our research first indicated the feasibility of a long-range supersonic cruise bomber. As you know, these research findings led to the initiation of the B–70 project by the Air Force. As our research to assist the bomber project became more specific as the design developed, we initiated generalized research to identify and solve the more difficult problems of the supersonic transport. This research has now progressed to about the same point as that which existed when the Air Force decided to start a design competition leading to the B–70. That is, the technical feasibility is established in our opinion in the sense that we can predict with confidence that a concerted and vigorous research and development program can lead to satisfactory solutions of the technical problems.

The first and most important technical problem for supersonic cruise airplanes is that of overall flight efficiency which determines the range that a supersonic bomber can fly and the economy of a supersonic transport.

My first chart, which is at my right and your left, shows the present state of the art as indicated by our research results. I have plotted flight efficiency against mach number which represents the airplane speed in terms of speed of sound. The efficiency of the present jet transports is seen to decrease rapidly as the speed of sound is approached.

Mr. FULTON. Will you give us in your chart, in miles, then, please, mach 1, 2, 3, and 4?

Mr. ABBOTT. At the altitudes at which this airplane will be flying, mach No. 1 is about 660 miles an hour; mach No. 3 is about 2,000 miles per hour, in round numbers.

The CHAIRMAN. Have you estimated mach 3 for the plane?

Mr. ABBOTT. I will have something more to say about that later, sir.

Mr. FULTON. What height is this, please, and temperature?

Mr. ABBOTT. The height will depend upon the detailed design of the airplane. However, it appears the general altitude should be on the order of 60,000 to 70,000 feet.

Mr. FULTON. So your mach number is at that altitude, and at what temperature?

Mr. ABBOTT. I am sorry, I forget the standard air temperature at that altitude. It is cold.

Mr. FULTON. Is it approximately —60° C.?

Mr. ABBOTT. Yes, sir.

Until recently the efficiency of all airplanes at supersonic speeds was very low. As the chart shows, however, it is possible to maintain efficiency up to three or even four times the speed of sound approximately equal to that of existing jet transports. These results hold the promise that actual flight operating costs could be about the same as for present jet transports.

I mentioned previously that the supersonic transport is a more difficult technical problem than the supersonic bomber. This increased difficulty stems primarily from the following requirements for the transport:

1. The fuselage volume must be larger to accommodate the passengers.
2. Each airplane should have a long operating life of many thousands of hours of flight to be economical.
3. The airplane must be compatible with the airports from which it is expected to operate, and with the traffic control system that can be brought into existence at the time the airplane goes ino service.
4. The airplane must be socially acceptable in the sense that it must not cause undue noise at or in the vicinity of the airport or over the routes it will be flown.
5. Safety requirements are even more stringent than for the bomber and more difficult to realize.
6. The airplane should have substantial growth potential to avoid large later developmental costs to achieve increased performance and to avoid the difficulties of bringing another completely new airplane into operation.

I obviously cannot discuss all these subjects here, but I would like to say a few words about some of the technical problems.

My next chart shows the structural temperatures for supersonic transport flying at an altitude of 70,000 feet. The temperature in degrees Fahrenheit is plotted against mach number for positions on the airplane wing 1 foot back of the leading edge and 100 feet back. The distance of 100 feet is just taken on this chart to show the nature of the spread that is likely to be realized over the aircraft which is not too great.

You will notice that a temperature of 300° F. is reached at about 2.5 times the speed of sound. This is about the practical limit for aluminum structures, though some recent information indicates this may be too high or unconservative. At three times the speed of sound, or about 2,000 miles per hour, the temperature is about 400° F. Such temperatures require materials such as stainless steel or, perhaps, titanium. These materials are at present excessively costly when fabricated in the manner required for this application. Much has been learned from the B–70 project, but much more work needs to be done to improve the structural design and fabrication methods to reduce the cost.

Many of the problems can be avoided, of course, by reducing the speed to the point where aluminum alloys can be used, about twice the speed of sound (about 1,300 miles per hour). Such a step to ease the immediate problems would introduce two problems for the future. First, such an airplane would have little or no growth potential as far as speed is concerned.

If it were found necessary to increase the speed, an entirely new development would have to be undertaken with the resulting delays

and costs. Secondly, little is known about the fatigue problems with aluminum at elevated temperatures and the consequent effects on the useful life of the airplane. This problem is much less critical for military airplanes, and no existing supersonic airplane has flown at such speed, or is likely to, for the long hours required of transport airplanes.

Further research can help this situation, but in this area there is no good substitute for flight experience. This is an example of one type of decision that will have to be made in the design that will affect the growth potential, cost, useful life, and possibly the safety of the aircraft. Research information to provide a sound basis for this decision will be required, and some of the studies are already getting underway.

I would also like to mention the noise problem. As far as engine noise is concerned, the situation is not much different than for existing jet transports except that more power will be needed and there will be a corresponding tendency for more noise. One way of avoiding this increased noise would be to use turbofan engines, which are also desirable for other reasons, but this would require the development of a new engine. While it appears entirely possible that some new engine can be developed which would both reduce the takeoff noise and provide improved performance and economy of operation, this item in itself will be an expensive undertaking.

A more important noise problem is that of the shock wave or pressure discontinuity which always accompanies a supersonic airplane. This wave sweeps along the ground below and behind the airplane causing a sudden noise which can be violent and which is known by the common name of sonic boom. This noise can be more than an annoyance because it is capable of breaking windows, causing plaster to fall, and other damage.

The NASA has done considerable research on this noise problem. We have established that, aside from meteorological conditions, the intensity depends on the altitude of flight, the speed, and the size of the airplane. The intensity cannot be reduced by changes of airplane configuration. Fortunately, the intensity is low when the airplane is flying at the very high altitudes required for economical cruise.

The sonic boom problem thus becomes important during the climb and letdown of the aircraft, because the speed should be subsonic to avoid this noise when the altitude is less than about 35,000 or 40,000 feet. The primary problem is in the climb because the configurations that are efficient at supersonic speeds are not efficient at subsonic speeds, and neither is the propulsion system. Consequently, the best supersonic configurations would use excessive fuel during the subsonic climb.

Such considerations will require the designer to compromise the configuration to obtain adequate subsonic performance. Ideally a change of configuration should be used if this is practical. Some configuration changes have been in use so long we take them for granted, and include retractable landing gears and the large wing flaps used for landing and takeoff. We are presently investigating configuration changes to increase the wing span at low speeds which appear to offer promise of large performance gains at subsonic speeds including climb, landing, and takeoff without introducing excessive complication and weight.

The supersonic transport poses formidable problems of piloting, navigation, and traffic control. Once it is in flight it must proceed along a precisely controlled flight path with little or no delays and with a large degree of dependence on automatic flight control and stabilization systems and rapid automatic traffic control over the entire route. A supersonic transportation system consists of not only the airplane but also the airport, navigation, and traffic control system within which it flies. The entire system must be engineered together to be compatible.

It is apparent that the supersonic transport presents formidable technical problems. I have dwelt on some of these problems in order not to mislead you about the magnitude and difficulty of the task. Nevertheless, we believe that these technical problems can be solved in an acceptable manner. We at NASA are proceeding with our research, but the time has now arrived when research by itself is not enough if progress is to be made at the rate that is technically possible. A concerted effort by Government and industry design teams is needed to bring the problems into focus and perspective and to enlist the talents and resources essential to such a difficult task.

In closing, I wish to thank you again for this opportunity to appear before you on this important subject and to assure you that NASA stands willing and able to do its part to assure the continued preeminence of this country in aeronautical transports.

The CHAIRMAN. Thank you, Mr. Abbott, for a very fine and enlightening statement.

I have a few questions I would like to ask you, sir.

You say this system has worked well for over 40 years. I assume you are referring to the system under NACA and the unique knowledge of operational requirements which that organization had.

Do you think that system should be continued?

Mr. ABBOTT. Yes, sir. I believe we have a very fine team effort in this country, between the industry, aeronautical industry, including both the manufacturing industry and the transport industry, and the various governmental agencies, including NASA, which does research. And I believe that this team effort is a very fine thing. It has worked successfully, and it should continue to work successfully to produce the supersonic transport.

The CHAIRMAN. Now, how much work has been done by NASA and its predecessor agency, NACA, on this problem of doing the basic research on supersonic jet transports?

Mr. ABBOTT. We have been working very actively on this subject now for about 3 years.

The CHAIRMAN. What percentage of the basic work has been completed?

Mr. ABBOTT. I think the basic research has now proceeded, as I said in the statement, to about the same state that existed for the supersonic bomber when the Air Force decided that enough information was available to proceed with the B–70 project.

The CHAIRMAN. Well, would you say that 50 percent of the basic research has been done?

Mr. ABBOTT. I think this is more than 50 percent of the work that is needed at this stage of the development; that is, I think we have established the basic feasibility in the sense that a vigorous effort can

now solve the remainder of the problems, and from this time forth the research by itself tends to become less and less valuable, unless it is accompanied by such a vigorous development program.

The CHAIRMAN. So if we do not intend to go ahead with a vigorous development program, we are really wasting money if we put any more effort on the basic research?

Mr. ABBOTT. If we do not decide to go ahead with a vigorous development program, I shall be forced to put this type of research on the "back burner," so to speak.

The CHAIRMAN. I think it is unthinkable that at this point we would turn our backs on supersonic air development.

Mr. ABBOTT. I agree with you completely.

The CHAIRMAN. There are some people who feel NASA has been putting forth all of its efforts on space research rather than putting a reasonable amount of effort in basic research on aircraft research and development. What have you to say about that?

Mr. ABBOTT. I am aware that those opinions exist, sir, and this has been a very trying problem for me. However, I do believe that we are continuing to fulfill our obligations in the areonautical research field. It is true that the magnitude of this research has decreased since we became NASA. However, I would like to point out that I think this magnitude would have decreased no matter what the organization was, just because technical developments in missiles and in space activities have taken some of the pressure off aeronautics.

However, in decreasing the amount of this magnitude, we have not decreased the vigor or the forward look of the research. We have tried to keep a vigorous program going, and I believe we have been very successful. We have tried to focus this program on the important aeronautical problems of the future, and have decreased it in those areas where the aeronautical industry and other Government agencies have become well equipped to carry on some types of work which NACA formerly did.

The CHAIRMAN. In other words, you are not reducing your goal, are you?

Mr. ABBOTT. We are not reducing our goal at all.

The CHAIRMAN. What is going to be the role of NASA in the development of a supersonic jet transport?

Mr. ABBOTT. We would assume that our role would be essentially the same as the role of NACA has been in the past, and that the role of NASA has been, for instance, in connection with the B–70 project. That is, we would expect to support the development technically in all possible ways, including whatever Government agencies had responsibility for the development and full support to industry and to the airlines in solving their problems.

The CHAIRMAN. You would not take the lead, but you would merely support with research?

Mr. ABBOTT. We would not recommend that NASA take the lead in this capability. We occupy neither the unique position in civil areonautics that is occupied by the Federal Aviation Agency, nor do we have within NASA the large procurement and technical organizations, such as the Air Force has, with experience in the procurement of large and complex aeronautical systems.

The CHAIRMAN. You think, then, the lead should be taken by the military? You make reference to the Air Force, and that is the reason I am asking this question.

Mr. ABBOTT. I believe I misspoke myself in mentioning the Federal Aviation Agency as an agency which surely should be considered. I think that——

The CHAIRMAN. You think the Federal Aviation Agency should take the lead in the development of a jet transport?

Mr. ABBOTT. Let me put it this way, sir: In the first place, whatever I say here has to be a reflection only of our thinking within NASA. These matters have not been discussed with the Bureau of the Budget, and, consequently, whatever I say cannot reflect any official position.

The CHAIRMAN. They have been discussed generally. That is why we have you here this morning, so we can discuss them.

Mr. ABBOTT. Yes, sir. We do have some views. Our views are that this project should be a truly national project, that it should involve the capabilities and talents that are available in this country, wherever they may be located.

Many of these talents and capabilities are located within NASA, and we would be willing and eager to contribute to this project in every way that we can and should.

Many of these talents and capabilities are also located in the manufacturing industry, both the airframe and the engine industry, and should be used to the utmost. Many of them are also located in the air transport industry, and certainly the airlines should have full participation in this project.

As far as the Government is concerned, certainly three agencies of Government need to be seriously considered: NASA, which I think I have already covered; the Federal Aviation Agency, which occupies a unique position in the civil transportation picture, and which is in a position not equaled by any other agency to combine the design and requirements of the machine itself with those that will be required to suit the traffic control airport system which will be available at the time the machine would come into operation.

The Air Force, also, surely should be considered, because it has the organization that is needed and which is well experienced in procuring large aircraft of this type.

I would say that serious consideration should be given to some kind of an organization which would use appropriately the talents of all these people, and I would point out that on a very much smaller scale this has been successful in some cases in the past.

I might point out the X–15 project as an example, which is a cooperative project with the Air Force, the Navy, and NASA, with industry having full participatiton in it. This project has been extremely successful, and I believe it could have been brought to success in the time that it has been only by this manner.

The CHAIRMAN. Well, now, would that envision a prototype plane first?

Mr. ABBOTT. I should think so; yes, sir.

The CHAIRMAN. In producing that prototype, then, each agency and private industry would participate. What you mean is that each one would make a contribution of funds and personnel to such a program; is that right?

Mr. ABBOTT. I think this would have to be the determination of the Congress, sir. I believe it would have to be formalized in some more specific manner than the X–15 project was, and certainly some one agency should be assigned by the Congress as having the primary cognizance of the thing, but with the expectation and direction, I would think, that this one agency would draw upon and use to their fullest capabilities the other two agencies which I have mentioned. I am not in a position to recommend——

The CHAIRMAN. And would request the other agencies, including private industry, to make suitable contributions?

Mr. ABBOTT. Yes, sir.

The CHAIRMAN. Why would you differ from the X–15 program?

Mr. ABBOTT. The X–15 program, of course, was handled by a cooperative agreement among the three agencies concerned, and the total cost of this thing was within the capabilities of the Air Force, with some contribution from the Navy, to finance. I think the supersonic transport will be a much larger project and will probably require separate consideration of the financing by the Congress.

The CHAIRMAN. Well, that brings us to the money question. What do you think this will cost? You have studied it as much as any man in America.

Mr. ABBOTT. I don't think, sir, I am the best man in America to estimate the cost of such a project. I think either the Air Force or industry would be in a much better position.

I would say, on the basis of past experience, though, it would cost much more than whatever the estimate will be. [Laughter.]

Including the whole system, I would be very much surprised if it came out less than $1 billion.

The CHAIRMAN. Well, suppose we set a billion dollars as the objective. You could make use of the experience thus far gained by the development of the B–70 program, couldn't you?

Mr. ABBOTT. Yes, sir.

The CHAIRMAN. But the B–70 program has been retarded, hasn't it?

Mr. ABBOTT. I am not aware it has been retarded, as far as producing a flying machine is concerned. The Air Force can speak to this later, if you wish.

The CHAIRMAN. There have been cutbacks; and I have not agreed with the cutbacks. I believe we have to have the B–70. But to the extent the B–70 program is pursued, in many respects that will parallel the basic developments in the jet transport program, will it not?

Mr. ABBOTT. I think the B–70 will be a very valuable experience and almost an essential one for the jet transport program; yes, sir.

The CHAIRMAN. So that one would complement the other, and the cost attributable to one could be applied to the other?

Mr. ABBOTT. Certainly, the transport will benefit tremendously from the experience through the B–70.

The CHAIRMAN. Do you think there should be developed two or more competing prototypes because of the enormous cost, or would you say it would be better to proceed, like the X–15, with only one prototype?

Mr. ABBOTT. This, I believe, sir, is something that should be the subject of a great deal of study by the cognizant agency, after this agency has been determined. I would guess, however, that the cost

would be so high that the tendency would be to proceed on a single prototype.

The CHAIRMAN. You have already stated in your opening statement that the financial cost to the passengers, or the customers, using this transport would be, or could be, made comparable to that of commercial aviation as we have it today.

Mr. ABBOTT. I believe this would be the case, providing the large development costs were absorbed in some manner.

The CHAIRMAN. To what extent will supersonic aircraft render present equipment systems and facilities obsolete? Will we be able to use the present facilities of the airport with this supersonic transport?

Mr. ABBOTT. I do not visualize the supersonic transport would make obsolete the large international-type airports which are now coming into operation, which are projected, such as the Dulles Airport here at Washington. It might be that some small extensions of runways, some increase in bearing loads on runways, some smoothing of runway surfaces would be required, and this sort of thing, but I would not visualize that a complete new network of airports would be required for such an airplane at all.

I do think, however, that it will require extensive revision to our air traffic control system. However, the FAA is much better qualified than I am to speak to this.

The CHAIRMAN. Well, of course, you wouldn't expect this type of aircraft to land in a small, local airport.

Mr. ABBOTT. No, sir; I would not.

The CHAIRMAN. Therefore, you wouldn't plan on modifying a local airport to meet the needs of a supersonic jet transport?

Mr. ABBOTT. I would expect the supersonic jet transport to be used only over long routes, such as transcontinental in the United States, and overocean routes, international routes.

The CHAIRMAN. You would expect them on a run, say, of a 2,000-mile minimum?

Mr. ABBOTT. This, of course, will depend greatly on the design studies that will have to be made, but it will be something of that order; yes, sir.

The CHAIRMAN. That would give them an hour in flight then.

Mr. ABBOTT. Yes. I would expect these long-range transports would be supported by a considerable network of feeder lines using various types of airplanes such as we have today, and it is also very true, of course, that most of our air traffic is over much shorter distances, and aircraft of the general types we use today would continue to be very useful for such purposes.

So, I do not anticipate the supersonic transport would do away with the other types of aircraft.

The CHAIRMAN. What carrying capacities would the prototype you have been doing basic research on have?

Mr. ABBOTT. We have been studying the scientific problems of these aircraft, including, of course, their configurations, but this does not involve us in questions of just how big the aircraft would be.

I think this, again, is a matter which should be decided after considerable study by the aircraft industry, including the airlines themselves, as to the size of transport which would be most economical and most practical on the largest number of routes.

The CHAIRMAN. The size could be varied?

Mr. ABBOTT. The size could be varied through wide limits. However, I do believe it would be a large airplane.

The CHAIRMAN. It would be larger than anything we presently use?

Mr. ABBOTT. I think it would be somewhat larger.

The CHAIRMAN. Suppose another nation, say Russia, develops such a transport and we don't; what is going to happen here?

Mr. ABBOTT. Well, I think, again, there would be something of the same type of "flurry" as happened after October 4, 1957.

The CHAIRMAN. Let's identify the date.

Mr. ABBOTT. That is the date of the first sputnik.

The CHAIRMAN. Yes. Sputnik No. 1.

Mr. ABBOTT. Sputnik No. 1.

The CHAIRMAN. You imagine a flurry similar to what we had after Sputnik No. 1?

Mr. ABBOTT. Yes, sir. However, I do not believe this is the reason we should proceed with the supersonic transport.

The CHAIRMAN. It always gives us a little push when we find out about Soviet successes.

Mr. ABBOTT. Yes, sir, this is a factor which has to be taken into consideration.

However, I believe this country should have the courage, the conviction, and the initiative to go ahead and do what is right, instead of always reacting to what somebody else does, or is likely to do.

The CHAIRMAN. If we develop a plane capable of speeds of 2,000 miles per hour, we could make delivery of personnel or freight as far away as Russia in 2½ hours, couldn't we?

Mr. ABBOTT. Something of that sort; yes, sir.

The CHAIRMAN. Of course, the reverse is also true. If we don't do it and Russia does, it could make delivery of personnel over here in 2½ hours.

Mr. ABBOTT. Yes, sir; nothing I said should be interpreted as depreciating the importance of these factors, including that of prestige.

The CHAIRMAN. I think it is extremely important. If, for instance, there should be a blowup in South Africa—and, I might add, our State Department has shown an interest in the affairs of South Africa recently—a supersonic transport could make delivery of personnel or freight there within a couple of hours' time.

Mr. ABBOTT. There is no question but what the supersonic transport would shrink the whole size of the world again in a manner which we have not seen since the airplane first replaced the ocean liner as a major means of transportation.

The CHAIRMAN. And with our global commitments all over the world, it would certainly make it far easier to maintain the security of our bases, and give us the ability to carry out our commitments more effectively; don't you agree?

Mr. ABBOTT. I do agree.

The CHAIRMAN. I could ask you many more questions, but my colleague, Mr. Moeller, has been very patient, and I want to give him a chance to ask some questions.

Mr. MOELLER. Mr. Chairman, you have asked many interesting and enlightening questions.

I would like to commend Mr. Abbott and members of NASA and his staff for this long-range thinking.

A number of questions have been brought to mind.

When you talk about this being a sort of national project, I assume you meant thereby that NASA, the various military departments, and other agencies of the Government would get into this thing, as far as the financing of the program is concerned.

However, how would a program be managed? Would this be a Government-operated line? Are we going to socialize some of our transportation in the United States because this thing is too big for private enterprise, and we therefore must recognize that maybe this is the way we will have to do it if we are to get it done?

Mr. ABBOTT. I would hope not, sir.

I should think that some arrangements whereby the Government picked up the check for the developmental costs, which will be very high in this case, would permit the aircraft then to be either bought or leased in whatever fashion the Congress considered appropriate by the airlines for their use. And that it would then prove to be a paying proposition for industry to use it in that manner.

Mr. MOELLER. But it looks right now as though the Government may have to pick up a "due bill," on some aircraft flying at the present time.

Mr. ABBOTT. Yes, sir.

Mr. MOELLER. This certainly isn't helping us.

Mr. ABBOTT. I would again like to point out I am a research man, who, I believe, knows something about the technical problems, but I do not consider myself qualified to discuss the areas into which you are getting now.

Mr. MOELLER. Of course, all your technical development will not help a whole lot unless this other can be worked out.

Mr. ABBOTT. I realize this very much. That is why I think the Government should take appropriate steps to assure this takes place, whatever they may be.

Mr. MOELLER. From your presentation, I'm not quite certain whether you would recommend a supersonic transport in the mach 2 or the mach 3 range.

There seem to be many, many advantages in staying at a mach 2, being able to use some of the existing facilities, and reducing some of the difficulties that you propose with respect to noise, et cetera.

Do you feel that maybe it would be cheaper in the long run to start with something of the order of mach 2 and stick with it?

Mr. ABBOTT. This is a matter which can be debated technically, and there is more than one school of thought.

However, I have rather definite views on the matter which I think are implied in my statement.

These views are that we should go directly to an airplane of the order of mach 3, which would then have growth potential to about mach 4. I say this because the only thing one really gains by going to a mach 2 airplane is the use of aluminum alloys for its construction, and a somewhat easier problem on the engine, but this, I do not believe is too important.

Now, the use of aluminum alloys for the construction in itself is going to bring in very many technical problems for which we do not have the answers—that is, the use of aluminum alloys, I believe, only looks superficially attractive. We do not know enough at the moment

about the fatigue life and characteristics of aluminum when operating at elevated temperatures over long periods of time to design aircraft out of aluminum for many, many hours of operation, which transports require.

Now much research can be done on this, but this is in an area where experience is an all-important factor, and we have lived for years on fatigue, on not only our research results, but on the actual experience obtained in flight. We would be lacking this experience, and consequently taking, I believe, a very considerable gamble in designing such an airplane.

Above all, it would be impossible to increase the speed of such an airplane because the temperature would go up and the structure would not be suitable. Consequently, if it were found necessary or desirable to increase the speed—and again, I might point out somebody else might build a mach 3 airplane while we had a mach 2 airplane, and it would for all practical purposes be necessary to start in all over again with all the costs of the development, and all the costs and worry of bringing a new airplane into airline operation, and these costs and times involved are not inconsiderable.

Mr. MOELLER. Well, what have we learned from the B–70 that would contribute to the development of either the mach 2 or mach 3 transport?

Mr. ABBOTT. The B–70, of course, is not limited to mach 2. Consequently we have gained—when I say "we," I mean the United States—has gained very considerable experience not only in the aerodynamic design, in the engine problem, but also in the structural problem of fabrication and using the materials that will be required.

The whole technology has to increase in order to make advances of this sort, so that in addition to these major problems that I mentioned, there are problems with respect to tires, landing gears, auxiliary equipment, and everything all the way through the airplane.

We will gain in this country an enormous amount of experience on all these things from the B–70 which would be of very great value.

Mr. MOELLER. May I ask one further question.

Do we know that the Soviet Union is doing anything at all in this field?

Mr. ABBOTT. I have heard rumors, sir, but as far as I am concerned, they are no more than rumors.

Mr. MOELLER. That is all, Mr. Chairman.

The CHAIRMAN. What was your answer to the last question about other nations working on this program?

Mr. ABBOTT. I have heard rumors that Russia is working on such an aircraft, but I have not heard anything that I can classify as any better than a rumor.

The CHAIRMAN. What about other nations? How about England?

Mr. ABBOTT. I think it is well known from press reports that England is showing a disposition to be serious in this matter.

The CHAIRMAN. I have been interested in the problem of metal fatigue. Can you tell when you are flying along whether or not metal is being weakened by fatigue?

Mr. ABBOTT. It has long been American practice to design aircraft in such a way that a single fatigue failure will not cause the destruc-

tion of the airplane. Consequently, through ground inspection in between flights, fatigue failures are found, and are corrected.

If the airplane is designed in such a manner that a fatigue failure will cause the destruction of the airplane, I believe it is improperly designed in the first place.

The CHAIRMAN. Then by proper ground inspection you can discover fatigue failure in metal?

Mr. ABBOTT. Yes.

The CHAIRMAN. So long as you have competent inspection at regular intervals, weaknesses caused by fatigue can be located and any potential difficulty can be eliminated?

Mr. ABBOTT. By and large, this is true, providing the airplane is designed with this in mind in the first place, as is the habit in this country for transport airplanes.

The CHAIRMAN. If you change the type of metal from aluminum alloys to stainless steel, or other metals, to provide higher heat resistance, are you going to get around problems of metal fatigue?

Mr. ABBOTT. Yes, sir, we are; and in my estimate the problem would be greater with the aluminum alloys operating at a speed of about mach 2 than would be the case with steel alloys operating at mach 3 or even 4, because the aluminum alloy is operating at temperatures which are higher for that alloy than the steel will be operating at somewhat higher temperatures.

I'm afraid I am not making myself clear, but steel is not seriously affected in its strength or properties at the temperatures that we are talking about, whereas the aluminum alloy is approaching an area where it is seriously affected in its properties, and we do not have long experience with aluminum alloys at these temperatures.

Much research can be done to help clarify these problems, and we are engaging in such research, but I would like to point out fatigue is an extremely complicated subject. Whether or not a given piece of material fails in fatigue at a given time is dependent on so many variables that it is almost impossible to determine accurately when this will occur. Consequently, we are dependent to a certain extent on experience in the fatigue problem, and this experience we do not have with aluminum alloys at elevated temperatures.

The CHAIRMAN. You seem to go much further in your statement. You say there is no substitute for experience. You just have to learn by bitter experience. That means that somebody has got to be a guinea pig as you learn, isn't that right?

Mr. ABBOTT. Yes, sir, except I do not believe that this statement should be carried to its logical conclusion; that is, if a material like steel is used, we do have a great deal of experience on steel, not necessarily in aeronautics, but throughout industry, and steel is a material about which a great deal is known.

The CHAIRMAN. Now, on one of your charts you referred to the lead end of the plane and the temperature, and then you also showed in that chart a distance of maybe 100 feet behind the lead end of the plane.

What effect would temperature, 100 feet behind the lead end of the plane, have on the plane?

Mr. ABBOTT. Oh, we could have that chart again. This chart showed a temperature at the leading edge of a surface and 100 feet

behind it, assuming the surface stretched 100 feet in that direction, but still on the surface, not behind the airplane. I would not draw the conclusion from this that the wing on the airplane would have a chord of 100 feet, but the 100 feet was chosen for this chart merely to indicate the rather small extent of the variation of temperature over the surface of the airplane.

The CHAIRMAN. In the event the plane were 100 feet long, there would be that variable in the temperature?

Mr. ABBOTT. That is correct; yes, sir.

The CHAIRMAN. That doesn't mean the temperature behind the lead edge of the wing would affect the plane itself?

Mr. ABBOTT. Temperature behind the leading edge?

The CHAIRMAN. Yes. You say 100 feet behind the leading edge.

Mr. ABBOTT. The leading edge is the forward edge of a surface in the air.

The CHAIRMAN. If you go 100 feet behind that, the temperature would not have any effect on the plane itself?

Mr. ABBOTT. If you go off the airplane, the temperature has no effect on the airplane itself. This chart was intended only to show that as one goes aft on the airplane, the temperature does decrease to some extent, but that the amount of this decrease is not very important. The main variation of temperature is with speed.

The CHAIRMAN. Are there any special medical or physiological problems in connection with supersonic flight?

Mr. ABBOTT. I do not know of any, sir. People have flown this fast successfully.

Mr. MOELLER. Will you yield, Mr. Chairman?

The CHAIRMAN. I yield.

Mr. MOELLER. What about cabin pressure; do you have any difficulty with maintaining cabin pressure at that altitude?

Mr. ABBOTT. Cabin pressure will be a problem, and this is one of the things I referred to in my statement when I said the safety problems will be more vigorous than the bomber and more severe. In the bomber, if the cabin fails for some purpose, the crew can and ordinarily will be equipped with a pressure suit which will save them.

It will be, I predict, impractical to fit passengers in general with pressure suits. Consequently, at these very high altitudes it will be absolutely essential that the cabin pressure not fail.

The CHAIRMAN. It would mean a matter of life and death if the cabin pressure should fail?

Mr. ABBOTT. Yes, sir. The passengers would die almost instantly if the cabin developed a leak.

The CHAIRMAN. Would passengers be given pressure suits to put on over their regular clothing? You don't think we would go that far, do you?

Mr. ABBOTT. I do not think we will go that far, sir. Pressure suits have to be pretty much tailored to the individual who wears them, and very carefully adjusted to him. I would not expect the average civilian passenger to either have a pressure suit available to him or be capable of using it satisfactorily in an emergency if he did have one.

The CHAIRMAN. The problems of ditching a supersonic aircraft would be very similar to the problems that you presently have in reference to planes now in service, aren't they?

Mr. ABBOTT. Yes, sir. I do not see any large differences in the ditching problems.

The CHAIRMAN. Would you have any difference in communications?

Mr. ABBOTT. No, sir. The only difference in communication would be the speed factor. The pilot has less time to make up his mind about things. Consequently, communications have to be positive and quick, but I see no particular technical problems at all.

The CHAIRMAN. A supersonic plane, however, would have to be able to reduce its speed from say 2,000 miles an hour down to 600 miles an hour before it could approach a landing strip?

Mr. ABBOTT. Oh, yes, sir. Moreover, I believe that these airplanes will require some measure of holding capability, although it is frequently said they will not be able to hold in traffic pattern; and to a certain extent this is true. Nevertheless, I believe that the realities of the situation will require that they be designed in such a manner as to have some minimum holding capacity over the airport.

The CHAIRMAN. Otherwise they may run into an impossible situation.

Mr. ABBOTT. Yes, sir. I believe this is very closely connected with the noise and turmoil problem, which I mentioned before, and indicates the airplane does have to be compromised to be at least a reasonably efficient subsonic airplane as well as a very efficient supersonic airplane.

The CHAIRMAN. As it approaches an airport, the plane would have to decelerate to less than the speed of sound at a very high altitude—above 40,000 feet?

Mr. ABBOTT. Yes, sir, and then come down subsonically.

The CHAIRMAN. And then come down subsonically. In the climb, too, you would have to retard its trip upward so as not to reach the sound barrier too quickly?

Mr. ABBOTT. It should climb at subsonic speeds until it has reached 35,000 or 40,000 feet, and then accelerate to a supersonic speed and continue its climb at supersonic speeds to the cruise altitude.

The CHAIRMAN. Have you any ideas how you would do that? Would the plane have a supercharger, or what would be needed?

Mr. ABBOTT. Yes, sir, there are ideas about how to do it, and I believe the committee has available to it some copies of a technical report which we have recently put out covering the general subject. This problem is one of the most serious problems for the supersonic transport, and is more serious for the supersonic transport than for the bomber, and will require that the airplane be designed to have reasonable subsonic performance. This can be done only in two ways: (1) By compromising the configuration, and (2) by changing the configuration between subsonic and supersonic speeds. We are now investigating means for changing configuration, and these means do look as though they might be practical. The fundamental problem here is that at subsonic speeds an airplane needs to have a wing which reaches out far to the side and catches a lot of air.

Consequently, all our subsonic airplanes have wings which stick out very far from their sides, as you may have noticed—that is, they have large wingspans. At supersonic speeds the airplane needs to be long in the direction of flight and slender otherwise.

The CHAIRMAN. More like a rocket.

Mr. ABBOTT. More like a rocket; yes, sir.

The CHAIRMAN. You indicate in your statement that you have a development which would increase the length of the wing.

Mr. ABBOTT. Yes, sir, we are working on such things. Actually, it is a variable sweep development, one in which the wing or a part of the wing would rotate in such a manner as to be swept back to have a small span at supersonic speeds and swept forward in order to reach out into the airstream like a subsonic wing when this is required. Now, this is a very difficult problem, both mechanically and aerodynamically, because when the wing configuration changes, the balance of the airplane must be maintained; and this is a very delicate balance. Consequently, for many years it was considered necessary if the wing sweep was changed to also move the wing fore and aft on the fuselage. This obviously incorporates mechanical problems which would increase the weight of the structure to such an extent as to make such a thing impractical. We have, however, found several configurations in which the balance of the machine can be maintained while the wing or portions of it are merely rotated about a pivot.

We believe this offers some very promising opportunities which need to be investigated by design teams to see whether they are as promising as we think they are now.

The CHAIRMAN. That would be a radical change, wouldn't it?

Mr. ABBOTT. Yes, sir.

Mr. MOELLER. Will the chairman yield?

The CHAIRMAN. Yes.

Mr. MOELLER. I understand that a good share of the wing in our modern aircraft is used for fuel storage. Now, this would be quite a problem, would it not, on your supersonic? What would you do about wing fuel storage?

Mr. ABBOTT. The supersonic will not use the wing for storage. The supersonic airplane will require a very thin wing. The drag of a wing at supersonic speeds increases approximately as the square of the thickness. You double the thickness, the drag of it goes up about four times. Consequently, there is a great premium on holding the wing thickness small, and storing the fuel in the fuselage or in the other streamlined bodies of large fineness ratio.

The CHAIRMAN. That is one of your biggest problems, isn't it—storage of suitable amounts of fuel?

Mr. ABBOTT. Yes, sir.

Mr. MOELLER. May I ask another question?

The CHAIRMAN. Surely.

Mr. MOELLER. Will you use a different type of fuel than you are presently using on jets?

Mr. ABBOTT. No, sir. Basically not. There might be minor changes in specification, but it would be essentially the same fuel.

Mr. MOELLER. We won't have to go out and develop a new fuel and then after we get it find out we can't use it?

Mr. ABBOTT. No, sir.

The CHAIRMAN. Have you thought of using rocket fuels of any sort?

Mr. ABBOTT. Yes, sir. Some consideration has been given to this. Rocket fuels taken as a whole also carry their oxidizer with them, of

course, and it is uneconomical to do this when one can use the oxygen out of the air. You may also be referring to other particular types of rocket fuels, such as hydrogen or possibly some of the boron fuels, or something of this sort. I believe these fuels are impractical and costly for an airplane that has to maintain itself in the air aerodynamically and economically.

Mr. MOELLER. Another question, Mr. Chairman.

If you were given the go-ahead signal as of today, how long would it take before this supersonic craft would be in operation?

Mr. ABBOTT. Reading the crystal ball is always dangerous, as you know, but I would estimate it would take 8 to 10 years to get these into commercial operation on scheduled routes—not to get the first airplane flying.

Mr. MOELLER. How about the prototype; how long will it take to get it out—3 to 5 years?

Mr. ABBOTT. Yes, 3 to 5 years would be a good guess.

The CHAIRMAN. What would you do when you got the prototype; would you wait 5 more years? It surely wouldn't take you 5 years to build one airplane of this type; would it?

Mr. ABBOTT. No, sir. When we get the prototype, I would expect there would be some problems with it which would have to be corrected.

The CHAIRMAN. You would get the bugs out first?

Mr. ABBOTT. We would get the bugs out first. Then, not from a single prototype, but a number of prototypes would need to be flown for an appreciable period of time in something approaching commercial operation over the systems that would be available for it to check out the whole transportation system before one would begin selling tickets to ride on it. As you know, there is considerable reluctance to kill large numbers of people in airplane crashes.

The CHAIRMAN. I would hope so. [Laughter.]

You have Mr. Milton Ames with you.

Mr. Ames, do you have a statement you would like to make?

Mr. AMES. No, sir. I was here to support Mr. Abbott. Thank you.

The CHAIRMAN. You rendered good support, too.

Mr. Abbott, we have two more witnesses this morning. You are not going to leave now, are you? Would you be available should the committee have further questions?

Mr. ABBOTT. Yes, I shall stay here as long as you wish.

The CHAIRMAN. We would appreciate it, because we have more questions we would like to ask, if time permits.

Mr. MOELLER. Would it be in order to explain not only to our witness, but to others, that a number of our members are meeting with the Foreign Affairs Committee this morning?

The CHAIRMAN. I have explained that.

Mr. MOELLER. You have already done so?

The CHAIRMAN. Yes.

Mr. ABBOTT. I might say I plan to be in town only today, though.

The CHAIRMAN. You came here today from where, Mr. Abbott?

Mr. ABBOTT. I flew down from New Hampshire for this hearing. I was fortunate in having a fishing trip.

The CHAIRMAN. We intend to finish today, even if we have to meet this afternoon. We certainly thank you for a very interesting statement.

Mr. ABBOTT. Thank you.

The CHAIRMAN. Now we will hear Major General Haugen.

General Haugen is Director of Development Planning—Deputy Chief of Staff, Development, U.S. Air Force.

We are pleased to have you here today, sir. Whom do you have with you this morning for the purposes of the reporter?

General HAUGEN. Mr. Chairman, I am accompanied by Col. Andrew S. Low and Col. Murdoch C. Campbell, both from Headquarters, Air Force.

The CHAIRMAN. We are happy to have you gentlemen here.

General Haugen, if you will proceed now with your prepared statement, we will listen attentively.

STATEMENT OF MAJ. GEN. VICTOR HAUGEN, DIRECTOR, DEVELOPMENT PLANNING, DEPARTMENT OF THE AIR FORCE; ACCOMPANIED BY COL. ANDREW S. LOW, AND COL. MURDOCH W. CAMPBELL, HEADQUARTERS, AIR FORCE

General HAUGEN. Thank you very much, Mr. Chairman.

Mr. Chairman and gentlemen of the committee, the Air Force is pleased to have its views with regard to a supersonic transport development program placed before your committee. It is a personal pleasure for me to have this opportunity to appear again before this distinguished group. I might add, it is a very great pleasure for me to follow my good friend, Mr. Abbott, not only because of the years of close association we have enjoyed, but because I heartily agree with his papers and his answers to your many cogent questions.

The Air Force has considerable factual knowledge, substantial experience, and background in supersonic flying upon which to base its views. "Busting the mach," or exceeding the speed of sound is an almost everyday experience in the Air Force, and no novelty to a great many of our rated personnel. We also have an extended history in the development and operation of transport aircraft. The supersonic transport appears to the Air Force as a natural evolution of our past experience in the development of new generation aircraft.

As late as 1956, examination of the potential of a supersonic transport did not present an optimistic picture. Designs based on the best knowledge of that time would probably have produced a monster aircraft of about 750,000 to a million pounds gross weight, capable only of a limited portion of its flight at supersonic speeds of mach 2 to 2.5, extremely costly to build and to operate, and requiring expanded airfields and ground facilities. In the past few years, however, advances in the fields of aerodynamics, propulsion, materials and methods of fabrication have approached the state where it can be predicted with assurance that an all-supersonic transport is technically and economically feasible.

Much of this advancement in technology is attributed to the stimulus given to research and development in the realm of high-speed flight by the need for supersonic bombardment aircraft. Historically,

new generation transport aircraft have sprung from earlier bomber technology and operation. The Air Force has conducted or sponsored a series of studies both in the supersonic bomber and supersonic transport fields.

While our interest has centered on technology and the advances necessary to supersonic flight we are also very conscious of the operational problems involved. I would like to discuss these briefly before considering the technical problems.

The ground support elements of a supersonic aircraft, including a supersonic transport system have been considered. According to our findings no serious problem is in evidence here. The expected weights of a supersonic transport, probably somewhere between 300,000 and 600,000 pounds, may require strengthening of runways and taxiways. The runway lengths of present international type airports are considered adequate for takeoff and landing. Existing airport facilities must be a design consideration for the aircraft.

The method of operation of the aircraft would influence performance to a high degree and therefore it must be considered in design. A mach 3 supersonic transport, traveling faster than a bullet fired from a high-speed rifle, cannot accept other than minor deviations from the planned flight path without serious effect on fuel economy. This sensitivity to the manner of operation, and the high penalty for carrying large fuel reserves, will not permit "holding" for any appreciable length of time, nor diversion to an alternate landing field. Fortunately, the short flight time associated with mach 3 operation should permit accurate terminal weather forecasting and landing reservations prior to departure.

Another problem which will plague the designer may be identified simply as noise. The sources of this noise are the engines, the aerodynamic boundary layer, and the shock waves. Engine noise, and its effects, as evidenced by sonic fatigue in aircraft structure and physiological discomfort or community annoyance, has been recognized for some time. Sound suppressors and operational procedures have been adopted as a partial solution. The higher power of the engines on supersonic transports would make the problem more severe.

Boundary layer noise is also a point of concern in present high subsonic operation, mainly from the standpoint of passenger comfort. In supersonic transport operation the hither energies involved will increase the annoyance and may result in damage to structure, unless adequate design measures are taken.

"Sonic booms" resulting from shock waves generated in supersonic flight could be a problem unless proper operating precautions are taken. The most likely time for annoyance, or even for minor ground damage to be caused would be during acceleration at low altitudes. This can be minimized by delaying acceleration to supersonic speed until an altitude of 40,000 feet or above has been reached. Above these altitudes the shock waves should be no more objectionable than momentary distant thunder.

Other problems may reveal themselves with the passage of time. Little is known about the environment of mach 3 and the high operational altitudes associated with this speed.

Mr. Chairman, as an aside, I might point out the X–15 program, the cooperative NASA–Air Force–Navy program, Mr. Abbott re-

ferred to, last week flew at mach 3 at 78,000 feet. It was piloted in this particular case by a NASA pilot.

The CHAIRMAN. At what altitude?

General HAUGEN. 78,000 foot altitude, sir. That is an approximate figure.

The CHAIRMAN. What about flutter and buffeting, General?

General HAUGEN. Those are always difficult to predict, as are also many design problems. Increased pressurization loads will introduce problems, variations in temperatures will complicate the problem of the structural integrity. These are all within the state of the art to control, however.

Now I would like to turn to the major design, engineering and production problems involved in supersonic flight and describe some of our findings.

As a result of research and testing, the configuration of future supersonic-manned aircraft indicates a characteristic trend in design. The flexible wing with fuel and engines distributed along the span will give way to the relatively thin, rigid, delta wings, and the concentration of high loads in the fuselage. The supersonic airplane will be required to operate over a much larger speed range than its predecessors. Consequently, its design features must allow for adequate stability, its design features must allow for adequate stability and control to meet the demands of varying flight conditions. Also design of flight-control systems must feature automatic provisions which free the pilots for only those functions requiring human judgment.

The optimum cruise speed for a supersonic transport cannot be defined exactly at this time. Selection of this speed depends on technical factors, but other considerations are involved also. As far as the technical factors are concerned, cruise efficiency deteriorates rapidly as an air vehicle passed through the speed of sound, or mach 1.0. However, once beyond mach 1.0, cruise efficiency improves as the speed of the vehicle increases through higher mach numbers and approaches that attainable with present-day subsonic aircraft. This gain produces new problems. As the mach number increases, aerodynamic heating of the skin of the vehicle is encountered, and the problem of dissipating this heat arises. The speed of mach 3.0 for the B–70 was selected as a design point, among other reasons, because it appeared to be the speed at which coolant capability became the limiting factor.

On the other hand, in designing for an optimum cruise speed, growth potential and intangibles, such as national prestige and the value of time, must play a part. They always favor higher speeds.

The principal technical factor which now permits attainment of a supersonic transport is the radical improvement in flight efficiency, which results in adequate range at acceptable fuel costs. Flight efficiency is the product of aerodynamic efficiency and propulsive efficiency. In considering aerodynamic efficiency we find that a drastic decrease in lift-to-drag ratio occurs when sonic speed is reached and passed. However, recent developments and design refinements, such as the compression lift principle, have substantially raised lift-drag ratios in the mach 3.0 region.

In compression lift design, the aircraft wing is positioned on the supersonic shock wave so that it derives additional lift from the in-

creased air pressure behind the wave. It may be said that, in effect, the airplane "rides" its own shock wave. Thus, we see that by proper design we can translate increased speed into improved aerodynamic efficiency. Furthermore, the attainable propulsive efficiency increases with increasing flight speed. The combination of the two factors produces flight efficiencies approaching those of present-day, high-subsonic aircraft. Still further improvement is anticipated in this area.

With regard to the powerplant for a supersonic transport, the current selection would be turbojet with afterburner or turbofan with duct augmentation. Such powerplants are more attractive for flight beyond mach 2. The high engine thrust-to-weight ratios obtainable with augmentation provides better acceleration and results in range improvement. As flight speed approaches mach 4, the conventional after burning turbojet becomes inadequate. Engine temperatures increase to such a degree that the internal machine must be eliminated in favor of a ramjet type of operation. However, a pure ramjet would not perform at the lower operating speeds. The answer to a propulsion system for mach 3.5–5 cruise speed appears to be a combining of the turbojet and ramjet into the hybrid turboramjet. This dual-nature engine would operate as a turbojet at the lower speeds and as a ramjet during cruises at and above mach 3.

Various fuels which might be used by these high-powered engines have been investigated. To date, a further refinement of JP, or kerosene-type fuels, still appears the most attractive. Of course, high energy fuels and nuclear propulsion still remain distinct future possibilities.

Airloads and temperatures of the supersonic high altitude environment demand changes from conventional materials of construction and fabrication techniques. The selection of materials and manufacturing methods are also determined by many other criteria, including the particular design or function of a component, the cost of fabrication, reliability, ease of maintenance and of course the strength-to-weight ratio. Also considered must be adaptability to methods of joining (that is, mechanical, brazing, welding), physical characteristics desired, resistance to corrosion, use as fuel containers and insulation properties.

The characteristics of conventional aluminum alloys limit their use as the prime structural material to a temperature of about 300° F. This temperature corresponds roughly to the temperature of an aircraft passing through the air at mach 2.4. At mach 3, the average temperature of an airplane due to this aerodynamic heating is 400° to perhaps 500° F. Here metals such as stainless steel or titanium alloy are required for the structure. Other metals present possibilities. Beryllium, for example, has an excellent strength-to-weight ratio at high temperatures, but it is relatively scarce, is costly to work, and is toxic. Nevertheless, it is suitable for certain large components where high strength and minimum size are desirable as in the landing gear.

Construction by the familiar method of skin and stringers riveted together is no longer acceptable for the mach 3 airplane. Stainless steel honeycomb sandwich panels, welded together by machine, are now needed to fulfill the exacting requirements. This change calls for

a virtual revolution in aircraft manufacturing methods and the design of radically new tooling.

Gentlemen, as you can judge, we have in hand much information and know-how on supersonic aircraft. It should not be inferred that all potential problems have been solved. There is much hard work ahead of us if a supersonic transport aircraft is to be a reality. Two sources of action present themselves toward the realization of a supersonic transport. The first and most direct would be the system approach; to design and build, from scratch as it were, an optimized supersonic transport vehicle. It has been estimated that such a program, once the requirement is firmly established, could result in an operational aircraft by 1968 or 1970. Its expense would be difficult to support unless it were preceded by the development of a manned bomber of similar characteristics.

In our view, a more practical route is by the way of an offshoot of the B–70 prototype development. At this time, the Air Force is developing a prototype mach 3 bomber and plans to expand this development to a strategic bomber force for the inventory. We have already expended almost 3 years of development effort and some $350 million on the B–70 program. By reason of this effort we are already far along the path that must be followed to develop a supersonic transport. While admittedly not optimized for a transport, an additional B–70 prototype vehicle could be configured to carry approximately 100 passengers and used to obtain the data necessary for the final design and operation of an optimized transport.

At such time as our B–70 developments confirm the utility of a transport configuration, such a prototype vehicle could be brought into service in a short time and with relative modest funding, as compared to an entirely new development.

It follows then that the technical and operational know-how, to be derived from such programs as the B–58 and B–70, can be the foundation of the next major advance into the supersonic regime.

In summary, the Air Force considers the development of a supersonic transport to be technically feasible, and a desirable national objective.

The Air Force believes that if the development of such an aircraft is undertaken it should be a national effort, combining the resources and talents of many agencies of Government and industry. The Air Force stands ready to serve in executive management of such a task.

This completes my prepared statement, and I would be most happy to answer any questions. Thank you.

The CHAIRMAN. Thank you, General, for a very informative statement.

There are many questions that come to mind.

You associate this program with the development of the B–58, or the B–70.

Hasn't there been a cutback in the B–70 program?

General HAUGEN. Yes, sir, the funds have been reduced from our former funds on the B–70 program.

As you know, formerly, we were proceeding on a weapon system development before producing a significant number of aircraft for the inventory, developing all aspects of the bombardment weapon system. That included ground support equipment, bombing and navigation subsystems, and many others.

The fund reduction has resulted in our present one prototype program and many of the military equipment items, such as bomb-navigation equipment is not now being built.

The date of first flight for the prototype—"empty" airplane—is about the same as it was in the original program.

The CHAIRMAN. What is that date?

General HAUGEN. We would hope to fly in December of 1962.

The CHAIRMAN. Then if you associate this program with the B–70, a great many of the problems which you encountered and which you solved in the handling of the B–70 program would be of assistance to you in this program?

General HAUGEN. Yes, sir; this is our view precisely, that we would have the basis for experience in the very problems that we will have to solve before a supersonic transport can be practical.

The CHAIRMAN. Will it reduce the cost of a supersonic jet transport?

General HAUGDEN. It would be the offshoot of a direct program; yes, sir.

The CHAIRMAN. And as Mr. Abbott says, in determining such things as fatigue of metals, only flight experience will do much good. You would get the necessary flight experience?

General HAUGEN. Yes, sir.

The CHAIRMAN. And be able to give the benefit of that experience to those who are designing and producing the transport.

Does this transport in itself have a military value to the Air Force, or to the services generally?

General HAUGEN. The military forces are very much interested in the possibilities of a supersonic transport. If such a transport were built as a national program, it is obvious that the military forces would wish to have and operate some of these transports.

We cannot at this time, however, so clearly delineate requirements for a supersonic military transport, that we could ask Congress for the money for this development as a purely military program.

The CHAIRMAN. You haven't reached the determination to ask Congress for funds for this purpose?

General HAUGEN. That is right, sir.

The CHAIRMAN. We will assume we establish the commercial need for this type of an airplane. Should they get together and come to you? Would it be possible in the normal operation of matters of this sort to work out a joint agreement, perhaps through NASA, perhaps through the Air Force, to develop such a transport?

General HAUGEN. Yes, indeed, Mr. Chairman.

In fact, we would like very much to join in such a cooperative program.

The CHAIRMAN. But you don't want to assume the whole burden of the cost?

General HAUGEN. We feel we have an "ongoing" program from which such a transport could spring expeditiously. We do stand ready to assist in a national program, in an executive management capacity, cooperating with all other agencies that are concerned.

We would need some help on the financing.

The CHAIRMAN. Well, now, if you had this transport plane, it would be a great advantage in keeping in touch with our oversea bases, would it not?

General HAUGEN. It would, indeed, sir.

The CHAIRMAN. It would help you solve many of your problems. Why do you say on page 7 of your statement that—

its expense would be difficult to support unless it were preceded by the development of a manned bomber of similar characteristics.

General HAUGEN. My reason for saying this, sir, is that we have spent to date, as I have said, 3 years of effort, very concentrated effort by a very large industrial team, which has cost us $350 million for the B–70 program.

This path would have to be retraced to a very considerable degree if we did not take advantage of such a program. In other words, to start a new program by itself, away from and not preceded by a military program would be extremely costly. You would have to retrace the steps and spend the same amount of money.

The CHAIRMAN. So that the basic research cost can be shared by both ventures, if we have both together?

General HAUGEN. Yes, sir.

The CHAIRMAN. Would one B–70 prototype provide enough flight experience for this purpose?

General HAUGEN. I would feel that this would be somewhat inadequate, Mr. Chairman.

If the Nation decided to go on such a program, it would be unwise to pin its hopes on only one vehicle, and we would say that a couple of prototypes—I don't mean two competing ventures, I mean two prototype aircraft—at least, would be a wise venture.

In fact, if we had resolution to go ahead with all possible dispatch to get into commercial and military operation, on a supersonic transport program, we would wish to expand it beyond two, and there would be a number of aircraft, the exact number of which I could not say at this moment.

The CHAIRMAN. I don't want to get into the cost of the B–70, but you refer to the B–58 in your statement. Why is it necessary to associate the transport program with the B–58?

General HAUGEN. Merely that this represents a considerable amount of experience in another supersonic speed regime, the cumulative total of which experience can be used to foster the supersonic transport development.

The CHAIRMAN. But is the design of the B–58, anything comparable to the proposed design of the transport?

General HAUGEN. I don't believe so, sir, but I think you will get a much better answer to that when some of the industrial representatives appear in the next day or two.

The CHAIRMAN. We have several days of hearings scheduled on this.

Mr. MOELLER. In view of the efforts put forth by our Government today—to speak of the use of outer space for peaceful purposes only, and in our hope to get the Soviet Union to believe our interests in this area—do you see any political implication in the use of such a speedy device as this?

What bearing might this have on foreign policy? Would this possibly add complications? I can well understand that the people of the Soviet Union will say: all right, they talk about using space for peaceful purposes, but here they come with a supersonic transport which is

in effect going to be bringing people hither and yon speedily for purposes other than peaceful uses.

Can you see some dangers involved here?

General HAUGEN. I don't believe I would see any more danger involved in carrying people at supersonic speeds than I would at any other speed or by any other medium.

Mr. MOELLER. I am sure they would say it is a matter of urgency for us to get these people around quickly. As the chairman stated before, if we had a little flareup in Africa, we might want to get men there right away.

General HAUGEN. Mr. Moeller, I fear I'm not able to answer your question very adequately. I have the feeling, however——

Mr. MOELLER. I know this is not in your realm, but I was just wondering whether you had given any thought to this possibility.

General HAUGEN. No, sir; I have not.

Mr. MOELLER. You have covered the field, Mr. Chairman.

The CHAIRMAN. Mr. Hammill is our counsel. Do you have any questions?

Mr. HAMMILL. I have just one, Mr. Chairman.

General, I wonder if you could give us the Air Force view on the possible impact on this country if the Soviet Union should develop a supersonic transport before the United States does.

General HAUGEN. I believe our view is about the same as that of any other American citizen. We would stand to lose a major battle on the prestige front. We would stand to see them have the advantages of the supersonic transport which have been alluded to earlier. And we would be in much more of a deficit position.

Mr. HAMMILL. Thank you.

The CHAIRMAN. Pursuing that question a little further; that would put the Soviets or any other nation in a position of being able to land equipment or personnel at a distant spot much more quickly than we could.

General HAUGEN. It would give them a tremendous advantage; yes, sir.

The CHAIRMAN. I think that covers the field very well.

Mr. Fulton.

Mr. FULTON. This question brings up the problem of why you don't design an all-purpose plane; that is, for operating at slow speeds and low altitudes, as well as high speeds and high altitudes.

Why don't you make your target a one-purpose vehicle. That is, a plane that would operate at high altitudes continuously without ever having to land or without ever having to come down through the denser atmosphere?

If you would plan on a type of plane that has the characteristics for landing and for going up at a high speed and returning with a good deceleration; then that plane that it goes to, would be kept in operation all the time. That brings up the question of what the optimum altitude would be and what the optimum speed would be. You can at this time fuel-test flying planes up there; there is no reason why you couldn't have a slot for your passengers too.

General HAUGEN. Mr. Fulton, we haven't gone that far in our studies.

Of course, in applications to potential space regions, such a thing becomes much more interesting.

Mr. FULTON. Yes, but I'm limiting it now to this area above 70,000 or 80,000 feet, rather than what you call space.

I am limiting it to the area of the atmosphere where you can get "lift" but don't want the characteristics of a low-flying plane once you get there.

General HAUGEN. The B–70, and the transport that we are suggesting here as an offshoot of the B–70, Mr. Fulton, would be optimized for those flight conditions at the extremely high altitudes of the 70,000- to 80,000-foot region, and mach 3 flight speeds.

The design would have to be able to operate at lower speeds, particularly for takeoff and landing.

We don't really feel that this is a major problem in coming up with a practical transport aircraft.

I might point out that the wing loading on such an aircraft would be extremely low, and it would hence have a great advantage, even though the physical shape of the airplane would not be the same as you would normally have for a low-speed aircraft. The very large wing would give you rather acceptable characteristics at low altitude.

This is simply a byproduct.

Mr. FULTON. Then we are not at the stage where you can design a plane for flight at a particular level which is the optimum level for your speed and the flying capacity you want? You don't think it should be divided.

General HAUGEN. It is, in a sense, divided. In the B–70 case, for instance, some of the variable geometry Mr. Abbott referred to earlier is used. The wing tips fold down for supersonic flight—they fold out for subsonic flight. They do that for a variety of reasons—to improve the efficiency at low altitude and low-speed conditions, and, conversely, when folded down, to improve efficiency and stability at high altitude, high-speed conditions.

In this sense, then, it is optimized to a degree for both conditions.

Mr. FULTON. My next question has to do with fuels. I'm interested in the development of high energy fuels for many purposes. I'm especially interested in research and development with respect to boron fuels.

General HAUGEN. Yes, sir.

Mr. FULTON. Would you tell us what is being done? I think we should push research on boron fuels. If we do, we will be able to determine the characteristics of such fuels with regard to their molecular and atomic weights.

The question is: How can we come up with a superfuel of this type? Would you tell us what is being done on boron fuels?

General HAUGEN. I believe the committee has been briefed much more adequately than I am capable of doing, on the boron fuels. Specifically for the transport, we would recommend that we give first attention to our conventional fuels, and to carry on with the research and development on the boron fuels for potential and possible application to this transport.

Mr. FULTON. I'm glad to hear that, because I am thinking ahead. If there is to be research and development on supersonic transports, we will likewise have to raise the energy value of our fuels so that we get a high specific impulse or thrust for the whole system.

Wouldn't you agree with that?

General HAUGEN. This would be a desirable goal. We would have to live, of course, with the limitations of such a fuel. There are many limitations, economic considerations being primary.

Mr. FULTON. But you do feel that boron fuels should be further investigated and researched, especially in connection with flight at high altitudes and very high speeds?

General HAUGEN. We should certainly keep our eyes open and continue our research toward this end; yes, sir.

The CHAIRMAN. Thank you very much, General.

We appreciate your very frank and candid statement.

General HAUGEN. Thank you, sir.

The CHAIRMAN. We have one more witness this morning, and that is Mr. John B. Montgomery, general manager of Flight Propulsion Division of the General Electric Co.

He is accompanied by Neil Burgess, manager of the commercial engine operation of the Flight Propulsion Division.

STATEMENT OF JOHN B. MONTGOMERY, GENERAL MANAGER, FLIGHT PROPULSION DIVISION, GENERAL ELECTRIC CO.; ACCOMPANIED BY NEIL BURGESS, MANAGER, COMMERCIAL ENGINE OPERATION, GENERAL ELECTRIC CO.

Mr. MONTGOMERY. Thank you, Mr. Chairman.

I am John B. Montgomery, general manager of the Flight Propulsion Division of the General Electric Co. and am responsible to the company for the design, development, and production of aircraft jet engines. May I express appreciation to the committee for this opportunity to present our views on propulsion as it relates to supersonic air transportation.

I have with me Mr. Neil Burgess, who has had 20 years of experience in the design of jet engines. He is manager of our commercial engine operation. He was corecipient of last year's Collier trophy award for his work in design and development of the J–79, our mach 2 supersonic jet engine.

My prepared remarks are restricted to aircraft propulsion and do not touch on the broader aspects involving considerations outside of the engine business. While I have sought throughout these remarks to be factual and informative, obviously it is not possible to exclude technical opinion entirely. We recognize, therefore, that others may disagree with our views.

First, I would like to summarize these views and thereafter offer some elaboration in support of our position.

We feel that within the present state of the art, it is possible to produce a jet engine for supersonic air transportation up to approximately 2,000 miles per hour—either military or commercial—which would be acceptable from the standpoints of efficiency, reliability, economy, and noise. This engine would be of the type we refer to as the fan burner, employing a fan, aft of the turbine, with injection and burning of fuel in the fan stream. It would operate on JP–6 fuel, currently available.

The engine could be produced within the time required to construct the airframe. The cost would depend on the size, specific characteristics, and the time available for development, but would be relatively

moderate since no new technical breakthroughs would be required. Beyond the speed range of approximately 2,000 miles per hour, additional state-of-the-art progress is required.

I would like now to describe the general characteristics of the various engine types and components, the collective technology of which adds up to the fan burner. But first permit me to review briefly General Electric's background in jet engines.

We have been active in the field of aircraft propulsion for more than 40 years, dating back to the first successful operation of an aircraft turbosupercharger on Pike's Peak during World War I. We have participated in the evolution of the airplane and the propulsion systems for three-fourths of the history of powered flight. General Electric has confidence in the future of air travel—not only as a means of transportation and commerce—but as an instrument of communication and understanding throughout the world. We are greatly pleased that the committee is taking a hard look at our national position in the area of supersonic air transportation.

In 1941, because of extensive experience with steam turbines and aircraft superchargers, General Electric was selected by the Army Air Corps to produce America's first turbojet engine. This engine was based on the pioneering efforts of Sir Frank Whittle of England. In October 1942, the first American jet-propelled aircraft, the Bell P–59, made its first flight powered by two of our engines. Successive models have followed in a continuous line of development, each more efficient than its predecessor. In approximately 20 years of production, General Electric has produced more than 30,000 engines of different types. These engines have compiled more than 27 million hours of flying time in various types of aircraft.

The more important engines developed by General Electric include the J–47, which now powers large fleets of Boeing B–47 bombers and North American F–86 fighters. General Electric developed the first American turboprop engine, the T–31, and is developing several outstanding small engines, such as the J–85. Our J–79, the first aircraft engine designed specifically for efficient flight at supersonic speeds, has been in production for 4 years and has logged more than half of the free world's flight time at high supersonic speeds. It powers the Air Force's Lockheed F–104 Starfighter and Convair B–58 Hustler, and the U.S. Navy's North American A3J Vigilante and McDonnell F4H Phantom II. The company's qualification to discuss supersonic propulsion is thus based in large part on substantial experience in flight at speeds of mach 2 and higher.

We have long been engaged in the study and development of propulsion systems for high mach aircraft. Nearly 10 years ago, preliminary design attention was directed to propulsion systems for use at and above mach 2. Design of J–79—the first mach 2 engine—was started nearly 8 years ago. Approximately 4 years ago, General Electric prepared a complete design for a mach 3 turbojet engine, and in May 1957, won an Air Force competition for such an engine, which is designated by the Air Force as the J–93. This engine was selected by the Air Force to power the North American B–70, mach 3 bomber. The engine program is well along, and qualification of the engine for military flight test is nearing completion. We have gained considerable knowledge and experience from the J–93 in its test programs at

our factory, not only under sea level test conditions, but also under conditions closely simulating supersonic flight at speeds up to mach 3.

As an engine manufacturer, it would not be appropriate for us to comment on the airframe itself, except as it specifically affects the propulsion system. For several years, however, we have worked with the country's major airframe manufacturers in their studies of supersonic transport aircraft, and feel that we can speak competently in those areas which are significant to us as an engine manufacturer, and significant to the airframe builders in solving the propulsion problem.

Much has been said concerning the problems of commercial supersonic flight. We believe it appropriate to select certain of those problems which concern the engine and identify what we believe to be possible and practical solutions.

I propose to discuss the several types of engines, the technology of which contributes to the fan burner, which we believe would be suitable to power the supersonic transport. We plan to use charts to explain the different approaches. These engines will be compared with respect to such considerations as noise, metallurgy, developmental problems, life, and reliability. These comparisons will be made on the premise that the supersonic transport might be derived from a supersonic military aircraft now in existence or under development, having basic characteristics acceptable to commercial operators.

First, I would like to invite attention to the first chart.

The simplest type of engine which we will consider is, of course, the straight jet engine. As shown on the chart, this type includes a compressor for the compression of air ahead of the combustor. Fuel is burned in the combustor, thereby increasing the temperature and hence the energy of the compressed air. The heated high pressure air then passes through a turbine, which produces the power for driving the compressor. Because the energy added in the combustor is more than the turbine requires to drive the compressor, an excess of energy is available. This excess energy makes it possible to exhaust the compressed air at high velocity, producing thrust.

This engine is identical in principle to the engines used in today's subsonic military and commercial aircraft, although today's subsonic designs would not, of course, be practical for high supersonic speeds. This type of engine has good fuel economy, but it would have to be large, and therefore very heavy, to provide the thrust necessary for a large supersonic aircraft. Such an engine would require noise suppressors of the type being used commercially today to reduce the noise of the jet exhaust. But even with these devices, however, noise levels would be extremely high. This engine must operate at high combustor temperatures to provide sufficient power. These high temperatures require very expensive materials and precise and expensive design techniques. Even then we would expect that the operating life before overhaul would be substantially less than the 1,000 hours now considered essential for economical commercial transportation. Furthermore, the thrust of this type of engine decreases rapidly when the engine is operated at air temperatures above standard. Therefore, in warm weather, either on the ground or in the air, a transport powered with such an engine would suffer penalties in payload and range. Engines of this type now under development are believed to be too

small to accomplish the required task, unless a larger number of engines are installed.

The next chart, please.

Another type of engine is the turbojet with afterburner, which now powers supersonic military aircraft throughout the world. The J79, used in the Convair B–58, and the J93, to be used in the B–70, are both engines of this type. As shown on this chart, the front part of the engine, or gas generator, is identical in principle to the straight turbojet. To increase performance, however, an afterburner is added. Additional fuel is burned in the afterburner to raise the energy in the exhaust stream, which in turn increases the exhaust velocity and therefore the thrust.

Afterburner engines have the characteristics of light weight, small size, and good performance, all of which are important to supersonic propulsion. Their fuel consumption, however, is quite high. In addition, the afterburner is an extremely noisy device which could well limit the operation of aircraft powered by such engines to military airports and other locations remote from heavily populated areas.

Although there is the possibility that the aircraft will be able to take off and complete the low altitude part of its climb with the afterburner turned off, at best the engines will be as noisy as the straight turbojet. The high noise levels of the afterburner engine result from the high operating temperatures which must be employed in the afterburner to obtain the desired thrust. These high temperatures, in turn, again require very excellent materials and precise design techniques. As in the case of the conventional turbojet, we would expect that the operating life before overhaul of such engines would be less than would be desired for economical commercial use. From the standpoint of reliability, however, it is believed that the afterburner engine could meet commercial requirements after appropriate military service experience.

In summary, the afterburner engine can successfully power the supersonic transport. It will be a noisy engine, and it will be an engine having shorter overhaul life than current commercial designs. Nevertheless, such an engine would do the job and, if the primary objective is to place an aircraft into operation at the earliest date—at the expense of operating economy and flexibility—it would probably be selected to power the supersonic transport.

The next chart, please.

There is a third type of engine which appears to overcome certain limitations of the straight turbojet and the turbojet with afterburner. This engine is the aft fan engine, which has been designed and is being produced for the most modern of our country's subsonic commercial transports.

The aft fan idea was first described in British technical literature during World War II, but because of aerodynamic limitations it did not become practical until a few years ago. In principle (as the chart shows), the aft fan operates by converting some of the energy in the exhaust of the straight jet engine into additional airflow. This additional airflow supplies a second exhaust jet which surrounds the main jet. This conversion of energy is accomplished in an assembly which combines a driving turbine and a fan compressor. The mechanical arrangement is such that the fan device can be designed for attachment to the turbine or exhaust end of the conventional turbojet.

Because the energy taken to drive the fan is more efficiently used in the fan engine, more thrust is produced without any increase in fuel consumption. In addition, although the engine handles a much greater airflow, the exhaust velocities are reduced and, therefore, the engine noise levels are reduced substantially. In this regard, it should be pointed out that exhaust velocity is by far the most important factor in jet noise. Even a small increase in jet velocity produces a large increase in the noise level.

The development of the aft fan engine in the General Electric Co. was initiated in 1957 to improve the characteristics of the jet engine for subsonic aircraft. The objective was increased engine thrust for takeoff and improved fuel economy for cruising. The development has been very successful, and engines incorporating this arrangement will enter commercial airline service in the Convair 990 aircraft in approximately 1 year with American Airlines and other carriers. When applied to the straight jet engine under subsonic conditions, addition of the aft fan offers approximately 40 percent improvement in takeoff thrust and 15 percent improvement in cruising fuel economy. These improvements have been demonstrated in both factory tests and flight tests. Furthermore, in spite of the greater thrust of the aft fan engine, noise levels are less objectionable than for the straight jets, because of low exhaust velocities.

The next chart, please.

As evidence of the good noise levels of the aft fan engine, this chart compares the expected noise levels of the Convair 990 powered by four aft fan engines with the noise levels of present commercial transports powered by straight jets. The decibel advantage of the 990 is highly significant because a change of three perceived decibels makes a 2-to-1 difference in the sound heard by the human ear.

The aft fan engine now in production at General Electric was developed for subsonic use, and in its present configuration would not be suitable for operation at high mach numbers. However, the fan principles which have proven so effective in our work to date show excellent promise for the supersonic engine. For example, it is possible to add the aft fan component in place of the afterburner to an engine such as the J93, and thereby make possible a supersonic engine having excellent operating characteristics at supersonic conditions.

The most interesting possibility, however, for application of the fan to supersonic use is to burn additional fuel in the exhaust of the fan itself. The heat added to the fan discharge air through this additional burning produces increases in thrust for takeoff and for supersonic flight.

As shown in this chart, the fan burner arrangement is similar in some respects to the afterburner used on the conventional turbojet. There are, however, fundamental and important differences. In the conventional afterburner, the objective is to burn the maximum possible amount of fuel and to operate the afterburner, therefore, at the highest permissible temperatures. This produces very high metal temperatures and consequent metallurgical problems. In the fan burner, on the other hand, the objective is to burn only the relatively small amount of fuel required to provide the desired levels of engine thrust. As a result, operating temperatures are much lower than for the afterburner engine and, consequently, it is possible to predict substantially longer engine life between overhauls.

It is appropriate to compare more precisely the operating temperatures of the afterburner engine and the fan burner engine. The afterburner engine, as designed for operation at mach 3, for example, operates at a turbine temperature of 2,000° Fahrenheit or higher, even under cruising conditions. This requires that the turbine blading in the engine be air-cooled in order to withstand the high stresses and the high temperatures to which the engine would be subjected while in operation. The air-cooled turbine blades represent an undesirable complication and, of course, increased cost. The afterburner of the afterburner engine would operate at temperatures of approximately 2,500° during cruising conditions, and even higher during takeoff and climb.

On the other hand, the fan burner engine would have a maximum turbine temperature of only 1,800°, which is the temperature being used today on commercial aircraft jet engines. Conventional fabrication techniques can, therefore, be used. Under cruising conditions at altitude, the fan burner engine will operate at a turbine temperature of approximately 1,700°. Temperatures in the fan burner itself will be low enough to permit a conservative design using known and developed materials.

We said earlier that the fan burner engine will be quieter than the other engine types we have discussed. As an approximation, one afterburner engine is expected to make as much noise as 16 fan burner engines running together, and the straight jet engine as much noise as 4 fan engines running together.

A major design consideration in the operation of the supersonic transport is the question of landing delays which may be encountered because of weather, air traffic, or similar factors. Once the supersonic aircraft has decelerated to subsonic speeds and descended to a moderate altitude, such as 10,000 to 20,000 feet to await landing instructions, it no longer has sufficient fuel to climb and accelerate back to supersonic speeds. Therefore, the terminal portion of the flight, which may be under adverse weather conditions and which may require sustained operation and possibly diversion to another airport must be performed at low altitudes and at low aircraft speeds. It is important, therefore, that the supersonic aircraft be able to hold or to divert to another airport without serious operating limitations. The aft-fan engine enjoys important advantages in fuel consumption at these low power and altitude conditions in comparison to the other two engine types. Therefore, the aircraft will not require an excessive amount of fuel to provide for holding or diversion to an alternate airport.

In summary, it is our opinion that the aft-fan engine with fan burning most nearly meets the requirements of the supersonic transport. Its operating characteristics in terms of thrust and fuel economy are well matched to the aircraft's needs, at both supersonic and subsonic speeds. Its noise level will be substantially lower than either the afterburning turbojet or the straight jet. Because it operates at relatively low temperatures, it can be expected to offer substanially greater life between overhauls. Furthermore, virtually all technology required for development of the aft-fan engine is understood and considerable operating experience is being gained under subsonic conditions. It is significant that the major airframe contractors,

who have been carefully considering the design problems of supersonic transports, regard this engine as being well suited to their needs.

No matter what type of turbine engine is selected for the supersonic transport, we do not visualize any great increase in problems connected with operation and maintenance on the ground. So far as ground handling, starting, and taxiing are concerned, the problems will be similar to those that today's jet transports face. As for maintenance, the engines admittedly will be somewhat more complex than today's commercial jet engines. But, with proper attention to powerplant accessibility in the design of the aircraft, and with properly trained ground crews, the transition from today's subsonic jets to tomorrow supersonic jets need not be difficult—so far as the propulsion system is concerned.

Program details with regard to the cost and timing of the powerplant development for a supersonic transport must necessarily await decisions on such fundamental aircraft design factors as speed, gross weight, range, payload and, of course, program timing. Our knowledge of the airframe industry's requirements, however, gives us assurance that either the afterburning turbojet or the fan burning engine can be developed to the required levels of performance, life, and reliability consistent with the time schedules of the airframe itself.

In our opinion, the engine need not await the development of new technology. A decision is required on the airframe itself, which in turn will define the engine requirements. Once the requirements are known, we believe that development can be planned, programed, and executed with confidence, and that the work can be successfully completed on schedule and at a cost which we believe will be a reasonable percentage of the total cost for the transport itself.

To conclude, we are confident that the propulsion system for the supersonic transport can be developed to the required levels of performance and reliability, on a time schedule consistent with the aircraft program.

We believe this to be true for speeds up to approximately 2,000 miles per hour. Beyond this, additional state-of-the-art progress is required. We do not believe that there need be serious operational limitations imposed by the powerplant. Based on our knowledge of work in the airframe industry, commercial use of the supersonic transport appears not only to be feasible and economic but also—in time—inevitable. We hope that we can contribute further to this important endeavor, and we stand ready to do so.

This concludes my statement, Mr. Chairman. Thank you.

The CHAIRMAN. Thank you very much, Mr. Montgomery.

You have given us a rather technical statement and yet it is one that we have been able to follow.

You have been very optimistic in your presentation to the committee. I understand that you have an exhibit here that you could show the committee.

Mr. MONTGOMERY. Yes, sir, we didn't know to what extent you would like to talk about engines, so we brought along a quarter-scale model.

The CHAIRMAN. We would like to see it, and we'll let you do the talking.

Mr. MONTGOMERY. This is an aft-fan engine. It is pretty hard from these charts to tell how the real fan works, and I thought this

would give you a better idea. So I will ask Mr. Burgess, if he will, to explain this aft attachment that we call the aft fan and how it generates more thrust and improves the fuel economy.

Mr. BURGESS. This is the model of a subsonic fan engine of much of the type we have discussed here this morning. This happens to be a J–79 gas generator. This portion here [indicating]—and the fan component in this case are designed specifically for a subsonic transport, the Convair 990.

The CHAIRMAN. I looked for the intake there.

Mr. BURGESS. The compressor is here for the main gas generator, the inlet is here for the fan. And there are two exhausts: This exhaust here for the main gas generator; another exhaust surrounding the main jet for the fan air.

Mr. FULTON. What is the patent coverage on the fan unit?

Mr. BURGESS. The basic idea was a British patent, which is now very old and almost in the public domain. General Electric has a license under the British patent.

Mr. FULTON. How much time to go yet on that basis?

Mr. BURGESS. It is about, I think, only 1 year; at the most two.

Mr. FULTON. Is there any basic patent that is necessary for the fan unit that is solely within the ownership of one company, or a license that is exclusive?

Mr. BURGESS. I am sure, Mr. Fulton, that there is not.

The classical components in the engine are the compressor, the combustor, the main turbine, the fan turbine and compressor, and in the case of the fan burner engine there will be an additional component added to the back which would include the burner for the fan airstream and a final exhaust nozzle, as shown in the chart on your left.

The CHAIRMAN. So that engine is not a fan burner?

Mr. BURGESS. This is not a fan burner engine, nor is it a supersonic engine, Mr. Chairman. This is a subsonic engine.

The CHAIRMAN. I see.

Mr. BURGESS. If this same principle were applied, for example, to the J–93, we would have a true supersonic engine. If we then added to that engine the fan burner, we would have a true supersonic engine having the advantages we have portrayed here in terms of economy and noise.

The CHAIRMAN. You are optimistic that with the use of the fan burner you can produce an engine that will propel an aircraft 2,000 miles an hour and can be modified in accordance with the frame design?

Mr. BURGESS. Yes, sir.

We base this optimism on development work which is already completed.

The CHAIRMAN. You say that the answer to a propulsion system for a mach 3 to 5 cruise speed appears to be a combination of the turbojet and the ramjet, a hybrid turbo-ramjet?

Mr. MONTGOMERY. That was General Haugen, Mr. Chairman.

The CHAIRMAN. Will you explain what he means? The general is still available—tell us what you mean, General.

General HAUGEN. Mr. Chairman, I had in mind a family of engines that might have the characteristics of a rotating gas generator with some kind of a ramjet after the fashion that Mr. Burgess has ex-

plained, or, as he has shown, a flow of air bypassing the main engine, in which air, fuel is burned, and it then operates much after the fashion of a ramjet—somewhat similar to Mr. Burgess' chart. This is one type of a hybrid engine which would be in the class that I was talking about. There are numbers of other arrangements that one could think of that would also be in this turbo-ramjet family of hybrid engines.

The CHAIRMAN. What you have in mind doesn't necessarily clash with the developments in General Electric?

General HAUGEN. No, sir, this is simply one manifestation of such an idea.

The CHAIRMAN. Mr. Moeller?

Mr. MOELLER. No questions.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. My question is, first, on the thrust as against the weight: Can you give us that ratio?

Mr. BURGESS. The thrust-to-weight ratio under takeoff conditions for engines of these types, supersonic engines, will be in the order of 5 to 6 pounds of thrust per pound of engine weight at takeoff.

Mr. FULTON. Can you convert the thrust into horsepower for us, please?

Mr. BURGESS. At very high supersonic speeds, for example, at mach 3, at 65,000 or 70,000 feet, an aircraft such as the B–70 has actually approximately 200,000 horsepower from its engines.

Mr. FULTON. Then would you give us the characteristics of the J–93, on the applications of the B–70, particularly with respect to the afterburner and the fan?

Mr. BURGESS. Within the limitations of the classified information, the afterburner J–93 and the fan burner J–93, would have quite similar characteristics in the supersonic application. The major differences would be that the fan burner is slightly larger in diameter. The afterburner engine is slightly lighter in weight. The fuel economies are roughly comparable.

In general, either engine could do the job within the limitations of the technical presentation we made this morning.

Mr. FULTON. For practical purposes, what would be the J–93 of that type—how would the practical purposes vary, considering this characteristic?

Mr. BURGESS. I would say that the principal advantage of the afterburner engine in the B–70 application is its small size plus the fact that there is substantial military experience already with afterburners. Therefore, this type of engine appears well suited to the military mission, where noise is of less importance.

Mr. FULTON. I do not want to take the committee's time at this point, but if you would, I would like a statement in the record, a little more adequately, on the patent situation on this type.

Mr. BURGESS. Yes.

(The information requested is as follows:)

GENERAL ELECTRIC CO.,
FLIGHT PROPULSION DIVISION,
Cincinnati, Ohio, May 20, 1960.

Hon. OVERTON BROOKS,
Chairman, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: The patent to which Mr. Burgess referred as covering broadly the aft fan arrangement was issued by the U.S. Patent Office on De-

cember 7, 1948, and accordingly expires on December 7, 1965. Since supersonic transports apparently will not be in operation prior to that date, this patent should have no effect in any program for such an aircraft.

We know of no patents which could be said to broadly cover the afterburning arrangement described in Mr. Montgomery's testimony.

Very truly yours,

H. H. GREEN, Jr., *Patent Counsel.*

Mr. FULTON. Next, on the cost, if you could, of an engine of the J–93 type compared to other types. Will you give us something on those costs?

Mr. BURGESS. I think the best way to answer the question, Mr. Fulton, is to say that major aircraft engine developments, the J–79, the J–57, the J–93, are of course costly. It seems to us that the——

Mr. FULTON. I am not talking about the research and development cost, I am talking about the production cost.

Mr. BURGESS. Production cost?

Mr. FULTON. Yes.

Mr. BURGESS. It has generally been a pretty good rule of thumb to consider the cost to be so many dollars per pound of engine thrust. I would not expect these engines to be more costly, measured against that criterion than today's engines.

Mr. FULTON. So that you aren't getting a level of cost that is different than the level that you now have per horsepower unit of thrust?

Mr. BURGESS. Correct.

The CHAIRMAN. May I ask you one question, Mr. Abbott?

Mr. Abbott, who is still here, said something about the problems of heat with increased speed. In fact, that problem runs through the whole hearing. I would like to ask this: If our problem of heat and the effect of heat on metal isn't just about the same as the problem in the missile program, that is the problem of bringing a missile back from the space areas into the dense atmosphere; isn't it a similar problem?

Mr. BURGESS. Speaking from the standpoint of the propulsion system, the engine itself, when operating at mach 3, sees somewhat higher temperatures than the structure of the airplane.

At mach 3 the temperature entering the engine, the temperature of the atmospheric air going into the engine is approximately 660° F.

We do not, however, face the same problem as the airframe designer, since classically American aircraft engines, American aircraft jet engines have been fabricated in steel. Therefore, we already have extensive know-how in steel construction at these temperatures, and do not have to worry about the conversion from aluminum to steel.

The CHAIRMAN. I don't understand why you say the air entering the engine has a temperature of 660°; is that what you said?

Mr. BURGESS. Yes.

The CHAIRMAN. The air certainly at cruising altitude would be around 70° below zero, wouldn't it?

Mr. BURGESS. The reason that the aircraft structure runs higher than the minus 70° is generally described as air friction. This is partly true, but there is another thermodynamic phenomenon, which says that when a molecule of air is stopped, as it hits the aircraft, energy is added to it, and this energy brings with it an increase in temperature.

The CHAIRMAN. But that air would be induced to enter the engine; it wouldn't be stopped. It would still have a higher temperature, wouldn't it?

Mr. BURGESS. The thermodynamicist considers that the air is stopped, and if you actually could place a thermometer in that location, you would measure these higher temperatures. So it is a technical design consideration.

The CHAIRMAN. We have time for one more question and then we have to adjourn to make a rollcall.

Mr. FULTON. The question is on the state of the art. Is the J–93 engine in shape so that it can be used for these supersonic transports without much modification; or do you need a major invention breakthrough yet?

Mr. BURGESS. Do you want to answer that one?

Mr. MONTGOMERY. We think the technology we have developed on the subsonic fan is applicable by redesign to the supersonic fan. We think the experience we gained in the afterburner can be applied to the fan burner. We have gotten about 13,000 hours so far in supersonic flight, and you might be interested to know that about 500 of those are at mach 2.

Mr. FULTON. That is a modification, and no basic change in configuration?

Mr. MONTGOMERY. This is a recombination of components so to speak, Mr. Fulton.

Mr. FULTON. You are at the point where the J–93 is practical for the supersonic transport?

Mr. MONTGOMERY. Yes, sir, from the state of the art.

The CHAIRMAN. If we are going to make a rollcall, we have to go very soon.

Mr. BURGESS. From the state of the art viewpoint. Much testing and developing still remains to be done.

Mr. MOELLER. I wondered if any of the witnesses had discussed the effects of the shock wave on other aircraft. I don't recall any. I wondered if it had been discussed.

There certainly would be some effect. I don't know who could give us the answer to this.

The CHAIRMAN. Mr. Abbott, could you put something in the record on that?

Mr. ABBOTT. Yes, sir, I would be happy to.

(The information requested is as follows:)

Several flight investigations have been accomplished at the NASA Flight Research Center, Edwards, Calif., in regard to the effects of a shock wave generated by a supersonic airplane on another airplane in flight. Pertinent results are noted in the following paragraphs.

In one series of tests, a Lockheed F–104 fighter airplane was flown at supersonic speed (mach numbers 1.2 and 1.8) about 500 feet to the side and below a subsonic Boeing KC–135 jet tanker which was flying at mach number 0.8 at an altitude of 35,000 feet. The tanker which is similiar in configuration to the Boeing 707 jet transport did not experience anything more than a slight bump. Angles of attack and sideslip measured on the KC–135 were extremely small and vertical tail loads as indicated by strain gages were found to be negligible.

In another series of flight tests, a North American F–100 fighter, a Lockheed F–104 fighter and a Convair B–58 bomber have been flown at supersonic mach numbers from 1.1 to 1.8 and at distances as close as 200 feet to another instrumented airplane which was used to measure the airflow fields due to the supersonic aircraft. The results indicated that the increase in mach number did not

appreciably increase the strength of the flow field or alter its shape. The peak pressure generated in these tests was a small percentage of the undisturbed, free-air pressure.

Tests have also been made wherein two supersonic aircraft passed each other at small separation distances, and the only effect was a noticeable but brief change in longitudinal trim. Apparently the only case wherein the shock wave produces a control problem is where one supersonic aircraft is flying close to and at nearly the same speed of another supersonic aircraft and remains in the shock field for a significant period of time.

Based on the above investigations undertaken at low supersonic speeds, it may be summarized that during normal operation of present-day subsonic transports, where appreciable separation distances are involved (1,000 feet or greater), the flow fields from a passing supersonic aircraft should not result in control problems, should not affect the structural integrity, and should not result in any appreciable displacement of the transport aircraft. For other than normal separation distances, as in "near misses," higher pressures will be imposed on the transport. Even in "near misses" by present operational supersonic aircraft at altitudes above 25,000 feet, the pressures are probably low enough and the pressure pulse of such short duration that there is little concern for the structure of a subsonic transport.

No experimental information is available on the effects of a shock wave generated by a supersonic transport flying at mach number 3. Determination of these effects from extrapolation of data obtained from the above tests is not warranted. Accordingly, this problem requires further research in order to reach definite conclusions.

The CHAIRMAN. As there are no further questions, the subcommittee will stand adjourned until tomorrow morning at 10 o'clock, and we want to thank the witnesses for all their fine statements.

(Whereupon, at 12:27 p.m., the hearing was adjourned until 10 a.m., May 18, 1960.)

SUPERSONIC AIR TRANSPORTS

WEDNESDAY, MAY 18, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SPECIAL INVESTIGATING SUBCOMMITTEE,
Washington, D.C.

The subcommittee met at 10:03 a.m., Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The subcommittee will come to order.

This morning, we shall have the pleasure of hearing an outstanding American, a specialist in aircraft, both civil and military, and a man who has made a brilliant record in the Air Force. He has done a great job building up our military reserves throughout the country, and he is now the Administrator of the Federal Aviation Agency. I refer to Gen. E. R. Quesada. We are delighted to have you, General.

This is the first opportunity we have had to welcome you before the Science and Astronautics Committee. All of us are pleased to have you here. Will you present those who are accompanying you this morning and give just a little bit of their backgrounds so the reporter can enter them in the record?

General QUESADA. Here on my right we have Mr. John Swihart, who is Chief of the Division of Advanced Configuration at the National Aeronautics and Space Administration, an outstanding aerophysicist who has contributed as much as anybody I know to the problem that you are discussing today.

This is Dr. Paul Cherington, professor of business administration at Harvard University, who in my opinion is the oustanding economist in the area of air transportation. He has done a great deal of work for the White House. He is the author of the so-called Cherington report that dealt with commercial aviation about a year and a half ago, and he is highly thought of in this area.

This is Col. Harrison R. Thyng. He is Chief of the Jet Plans Division, Federal Aviation Agency. He is an officer of the Air Force assigned to the Agency.

I would like to say that I am very happy to have an association with this committee, and particularly the chairman again, and I am delighted to be here.

The CHAIRMAN. Thank you, General. You have a prepared statement. I think it would be appropriate to proceed with that statement.

STATEMENT OF GEN. ELWOOD R. QUESADA, ADMINISTRATOR, FEDERAL AVIATION AGENCY; ACCOMPANIED BY JOHN SWIHART, CHIEF, DIVISION OF ADVANCED CONFIGURATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; DR. PAUL CHERINGTON, PROFESSOR, BUSINESS ADMINISTRATION, HARVARD UNIVERSITY; AND COL. HARRISON R. THYNG, CHIEF, JET PLANS DIVISION, FEDERAL AVIATION AGENCY

General QUESADA. I want to thank you for inviting the Federal Aviation Agency to appear before you today on the subject of the possible development of a supersonic commercial aircraft.

Under the Federal Aviation Act of 1958, the Administrator of this Agency is generally empowered and directed to foster development of civil aeronautics in the United States and abroad. More specifically, under section 312(b) of the act, the Administrator has authority to undertake and supervise developmental work and service testing for creation of improved aircraft. In addition, as you know, the Agency has responsibility for certification of civil aircraft from the standpoint of aviation safety.

We are particularly interested at this time in the possible development of a supersonic commercial aircraft, because development of civil aviation has reached a rather unique point in history. For many years the needs of military aviation for higher performance aircraft, and the military priority placed upon their development, have put us in the position of always having advanced military developments to call upon for application to the needs of civil aviation. Thus, commercial transport aircraft have largely stemmed from a military counterpart already in being, or at least from prior military development of powerplants or major components. Although development of commercial types has involved sizable investments by the aircraft industry, extensive assistance was available from Government-financed research and development.

In the supersonic field there is no advanced military airplane configuration easily adaptable to conversion for civil transport use. Hence, there is a very real prospect that unless some new approach is taken toward development of a supersonic transport, further progress toward such a civil aircraft may not take place.

This situation is also complicated by the fact that the next commercial aircraft of which we are speaking, a supersonic transport, would represent the greatest incremental advance in speed ever contemplated in a single step. In going from our present subsonic jets, capable of speeds approximating 600 miles per hour, to supersonic jets, we are considering airplanes capable of traveling at three times the speed of sound.

This represents more progress, in terms of aircraft speed performance, than we have seen in the first 50 years of aviation history. The change from the present jets to a supersonic aircraft has been likened to proceeding from a DC–3 directly to a DC–8. As you know, the DC–3 was the first widely used airline transport, developed in 1935 to carry 18 passengers at speeds up to 165 miles per hour. The DC–8 is one of the very latest jet transports, designed to carry up to 150 passengers at speeds up to 600 miles per hour. While this presents a

real challenge to civil aviation, it is nothing more than our Nation has come to expect as normal accomplishment in a dynamic field.

In the way of background, I would now like to turn to some of the background necessary for a thorough understanding of where we stand today. Ever since the Wright brothers' memorable accomplishment in 1903, the Military Establishment has had a vigorous development program designed to meet their needs for increasingly high performance aircraft. The pressing demands of national defense have characteristically given precedence to military budgets for this purpose.

After designs were fixed and quantity production established to meet military requiremnets, it was often possible to build adaptations for purchase by air carriers and use in the civil fleet. This has been especially true in the development of crucial components such as engines and propellers, as well as materials and techniques of design. Thus, for over 55 years commercial aviation has had the advantage of leaning on and borrowing from a strong military development program.

As we are all aware, however, the past few years have seen a decided shift from military aircraft to rockets and missiles. This has been accompanied by a drastic change in allocation of procurement and development funds in the Military Establishment. The introduction of civil space activity has further accentuated this trend.

Although the wisdom of this shift in emphasis is not open to any serious question, it has already begun to leave its mark on aircraft development. Its impact was first felt on support aircraft for military purposes, such as cargo types, then on jet fighters and other types of attack aircraft. This year, the Air Force's primary bomber project, the B–70, has also felt the impact.

It is true that proven military aircraft are daily flying from mach 1 to mach 2 speed regimes. However, I am informed by technical sources that these designs are unsuitable for commercial adaptation. Thus, with the change in the traditional cycle of development I have just described, civil aviation finds itself today at a definite crossroads in the path of progress.

At this point, we might ask ourselves why the United States should be interested in the possible development of a supersonic commercial aircraft. I hardly need to stress the value of our continued world leadership in the promotion of civil aeronautics. We have all seen the tremendous impact of being first to have a successful modern commercial jet, widely used throughout the free world. Our supremacy as a producer of the world's civil transport aircraft is an enviable position, of great importance to our economy and to our national prestige. It goes without saying that foreign competition in production of aircraft is earnestly and effectively striving to make inroads on our position.

The current consideration of the problem: Late last year I selected a special group within FAA to investigate the planning action necessary for development of a supersonic commercial aircraft. In November a special trip was made to the Langely Research Center of the National Aeronautics and Space Administration for the purpose of investigating the technical feasibility aspects of the problem.

In response to our request, NASA not only furnished all their existing data, but also performed additional studies dealing primarily with the characteristics for civil air operation, and presented a comprehensive report on the subject in December. The results of these preliminary studies indicate very clearly the technical feasibility of speeds in the mach 3 region. They further indicate the interesting possibility of incorporating in these very high performance aircraft some of the better efficiency and handling characteristics embodied in some of our present day jet aircraft.

Currently with this technical feasibility investigation, the planning team has conducted a series of visits to most of the major engine and airframe manufacturers. Many of these firms have been studying supersonic transport development for some time, and they presented us with their preliminary studies.

Close working arrangements have also been established with the military organizations which are currently developing and operating supersonic aircraft. In this way, we are keeping abreast of current activities in this field, such as performance, operations, training, and maintenance.

While these studies of technical feasibility are reassuring, a major role of this agency is to determine commercial feasibility in light of the state of the art. Accordingly, we are conducting an investigation of the commercial feasibility of supersonic transports with respect to development costs, manufacturing costs, operating costs, and market analysis. This investigation includes consideration of data furnished by both military and civil organizations.

The preliminary conclusions reached indicate that supersonic transports are economically feasible for commercial airline operation and that there will be a reasonable commercial market for such aircraft. The data prepared indicates that operating costs would be generally in line with those for current subsonic jet transports. However, because of the large amount of costly developmental work required, it is apparent that such costs will be too large to be borne by a single airplane producer.

It might be well to emphasize at this point that our supersonic planning is only in the initial investigative stage. Our findings to date indicate that further careful advance planning will be required. Research and development have not progressed to the point where definitive project decisions can be made on any reasonable basis.

Our studies to date have brought out many complex technical problems. While we are fairly well along in developing jet engines capable of powering supersonic military bombers, we do not yet have the civil counterpart with proper performance characteristics for economic airline operation. In this connection, we feel the economic and commercial aspects of the problem will prove just as complex as the purely technical aspects. Moreover, although we have had considerable experience in military research and development programs, there has been little experience in any comparable development program for a civil aircraft.

There is no question but that we must continue our advance planning if we are to achieve early success.

Environmental factors: Although we are not in a position at the present time to determine the nature and extent of governmental par-

ticipation in developing a supersonic commercial aircraft, I would like to emphasize at this time certain basic premises on which any such participation should be based, when and if it is proposed.

The first is that the new aircraft must be generally compatible with the runway lengths of existing airports.

As you know, throughout the history of aviation, every new transport, when introduced, required increased runway lengths. The situation has been recently aggravated by introduction of the current subsonic jet transports. This was caused by several factors. The change from propeller to jet propulsion reduced the thrust available for takeoff and increased wing loadings. This had the effect of increasing the speed needed for takeoff, since there was a relatively low ratio of power to the weight of the aircraft. The result was an increase in runway requirements up to 10,800 feet in some cases. However, these same characteristics made the aircraft efficient in its ability to cruise and carry passengers at a high rate of speed.

On the other hand, the supersonic transport, instead of needing relatively small amounts of power for cruising, requires substantially greater amounts of power at the higher speed ranges. Moreover, even higher power is required to make the transition through the speed of sound.

Since the airplane will be flying at higher altitudes, it will require larger wing areas. The result is that these large wing areas, combined with large amounts of installed power, should be favorable toward keeping the runway lengths for takeoff within existing criteria. Studies conducted by NASA indicate that we should be able to live within present day runway lengths. I must emphasize this is a very important factor, not only for the Federal Government, but for the community as well.

In this connection, it might interest the committee to know that the runways at Dulles Airport have been designed to accommodate aircraft with a gross weight up to 500,000 pounds and with landing gear loads similar to those of the Boeing 707. Some of our current jet transports weigh in the order of 300,000 pounds. Preliminary studies indicate that a satisfactory supersonic configuration capable of carrying about 110 to 125 passengers from New York to Paris would weigh about 375,000 pounds, so at Dulles we are within our criteria.

One of the factors which affect the gross weight of aircraft, of course, is the amount of reserve fuel required, which is largely based upon FAA regulations designed to meet safety and air traffic requirements. It is a vital part of our planning effort to evaluate such considerations well in advance of design of an actual airplane.

With respect to the expected volume of supersonic aircraft operations, as it relates to the usability of existing airports, our tentative conclusion is that this should not present any particular difficulties. Our market surveys of the demand for supersonic air service indicate a frequency of operation which can be accommodated by modern airports now used by subsonic jets.

This Agency's planning for supersonic commercial operations must also take account of the need for compatibility with the air traffic control system. There are a number of practical operating considerations which could cause difficulties in accepting these high perform-

ance aircraft into the system, unless we start thinking now of solutions to the problems presented.

Another major condition which should be placed upon any Government participation in supersonic aircraft development is acceptability of the aircraft in terms of noise. A major premise which must be kept in mind from the outset in developing such an aircraft is that any need for increased power should be met without increased noise. The use of ducted-fan engines offers some promise of noise reduction below the level produced by current turbojet engines of comparable thrust.

In addition to engine noise, the supersonic aircraft presents a potential problem through creation of sonic booms. Preliminary studies indicate that climbing subsonically to a sufficiently high altitude, prior to transition to supersonic speed, will probably meet the sonic boom problem effectively. There is a divergence of opinion here, however.

With respect to all these environmental factors, careful advance planning is necessary to produce favorable results. In the past we have developed aircraft first and then tried to cope with the resulting problems. If it is made clear from the outset that the next generation of aircraft must be compatible with the flying environment, there is no reason why we cannot enjoy the benefits of further aviation progress without suffering any offsetting penalties.

In conclusion, I would like to make it crystal clear that our thinking in this area is only in the very preliminary planning stage. The problems of administration, development, financing, and economics are really extremely complex. These problems are actively under study, and I am sure they can be resolved. We in the Federal Aviation Agency intend to pursue our present source of planning and investigation, working toward a definite program, so that the administration will be in a position to present appropppriate recommendations to the Congress at the earliest practicable date.

I have six graphic illustrations which will highlight some of the points I have discussed.

While they are being prepared and having indicated that a supersonic transport is feasible, I would like to bring up at the same time there are some very significant factors that are different between a commercial supersonic jet transport and a military supersonic jet bomber.

As an example, the reliability of the cabin environment must be beyond question. It is unreasonable to expect that the crew of a commercial supersonic transport could be ejected in a capsule as is the case in supersonic bombers. There are other factors that apply to the development of a supersonic transport, such as the necessity for temperature control. The exterior temperatures on the skin will be in the neighborhood of 400°. It must be crystal clear there must be no possibility of these temperatures being transmitted into the cabin.

Breathing oxygen must be without the possibility of failure. This presents the problem of ultraviolet rays producing ozone; the oxygen within the cabin must be ozone free. Ozone is toxic. The pressure of the cabin must be incapable of compromise. Decompression at the altitudes that we are considering—that the operations will take place at would bring catastrophic disaster.

The reliability of the control system must be such that normal and modest turns do not produce excessive forces either positive or nega-

tive. The control surface must be really reliable to a degree that is not subject to challenge. There is unknown turbulent conditions at the higher altitudes, but this is a factor which is subject to easy determination.

The subject of the sonic boom to which rather casual and perhaps glib reference was made, this indicates that careful consideration must be given to the areas in which this type of airplane can be operated. Public acceptance of this supersonic boom must be investigated. It might be worthy to note that the Air Force is conducting this summer a whole series of tests that will give us a great deal more information on the subject of the supersonic boom than we now have. This is a subject in which there are varying views.

With that in mind, perhaps before you ask questions, or if you wanted to ask questions——

The CHAIRMAN. Let's see your charts first.

Mr. SWIHART. We have on this chart speed in miles per hour plotted against time. You see back in here in 1935 the DC–3 at about 160 miles an hour. The DC–7 nearly 300; the 707 at about 600. If we extrapolate this curve, we come to mach 3 and in 1970 with mach 3 speeds with roughly 2,000 miles per hour.

You speak of a trip from New York to Paris. Yesterday there was some reference to a trip of this nature about 3,500 nautical miles. We have here trip time plotted against cruise speed. The speed in the current subsonic jet takes about 7 hours.

An airplane flying at about 2,000 miles an hour would take roughly 2 hours and 20 minutes. This is a threefold increase in speed and threefold increase in productivity of a given airplane.

This is a seat-mile cost. This is direct operating cost and cents per seat-mile against the range of the airplane. In this direct operating cost are the crew, the depreciation, the fuel, maintenance, and insurance. We have here this red band for the present subsonic jets. In this blue band we have the supersonic transport.

You see, the airplane appears to be economically competitive with the subsonic jet over the kind of ranges that we are talking about.

General Quesada referred to the takeoff runway of the supersonic jet transport. We have here an isometric chart of altitude against range from the start of the takeoff role. The subsonic jet takes off here at about 2 miles and climbs on a path like this, but the supersonic jet would takeoff on approximately the same runway but would climb steeper, much steeper. This gets into the noise problem on the ground and at any given point out here there should be less noise on the ground from the supersonic transport.

This is just an indication of what a real long-range supersonic transport might mean in terms of trip time from say New York to Honolulu. The subsonic jet now makes this trip with one stop to San Francisco in roughly 9 hours and 31 minutes. The trip from New York to Honolulu is calculated to be about 3 hours and 14 minutes by a supersonic jet. Again this is a threefold increase in speed and reduction to one-third of the trip time.

General QUESADA. The thrust of this short presentation was to bring to the committee's attention again what it already knows, and that is that when we speak of supersonic jet transports, we are not taking a step of evolution but more a step of revolution. It is a substantial step.

The CHAIRMAN. It is a substantial step because you are stepping up from 600 to 2,000 miles per hour.

General QUESADA. It is a step that is revolutionary in techniques. Certainly revolutionary in performance, and we have to find some answers to questions that are raised at this time, not resolved, technical questions as well.

The CHAIRMAN. I think you have made an excellent statement. It seems to me you have answered most of my questions.

From what you say and what the chart shows, it would seem to me the noise factor would be less objectionable in the case of supersonic jet transport than it is to the present jet.

General QUESADA. When you consider the engines that are in the offing and we have learned to have confidence in the ability of the engine manufacturers to produce what they say they can produce, your statement is true.

The CHAIRMAN. Yesterday a representative of the General Electric Co. said that they will be ready with an engine whenever the airframe is ready. They are confident that they can produce an engine that will propel this aircraft 2,000 miles an hour through the upper stratas of the air.

General QUESADA. I would like to bring to the committee's attention again what it already knows; it is not unique to determine what you want at some future date, and specify then at the time you determine it that you need an engine of certain characteristics, when that engine in fact does not in fact exist today. This is a practice to which we are accustomed. We often design airplanes requiring a propulsion system that is not in existence at the time you lay the airplane down. This is a common practice. It is a practice that has proven reliable and successful.

The CHAIRMAN. Do you disagree with the testimony given us yesterday in that respect by General Electric?

General QUESADA. No, I am saying I do agree with it.

The CHAIRMAN. Fine.

Going back to your statement; I think it is an excellent statement, General. You brought up a number of things. For instance, you say that in the supersonic field there is no advanced military airplane configuration easily adaptable to conversion to civil use.

General QUESADA. The only supersonic airplane that is in the same area is obviously the B–70. The B–70 is being developed for the Military Establishment, as you know, and it has in it military characteristics that are not acceptable for commercial operation. Admittedly the B–70 program will bring to us the answer to many questions that have been raised, and as I said before, the answer is not easily available. This airplane will certainly advance the state of the art. It will give us a great deal of data that relates to the structure, but when it comes to carrying 100-some passengers, there has to be ground into it a degree of reliability that is not essential to military aircraft. You have to attempt to get the operating costs down which are not so essential to military aircraft. The differences are quite great when you delve into it. There are many characteristics in the B–70 that would not under any circumstances be acceptable for commercial use.

The CHAIRMAN. General Haugen yesterday stated that he thought this transport would be a natural offshoot from the B–70 prototype

and that it might easily be configured to meet the needs of the transport type plane.

Do you agree to that?

General QUESADA. If that is said in a very broad sense, I do. I am sure there are many advantages that the B–70 would contribute to the development of a transport, but the configuration as it is now could not be used as a transport. It could conceivably be redesigned and the wing structure and the manner in which they fold back and into the fuselage might well turn out to be the accepted method.

The construction, the honeycomb steel construction that the B–70 is using might well turn out to be the accepted method. The control system of the B–70 will certainly contribute materially and in a major way to a commercial transport.

To go to the negative, the cubic volume of the B–70 is considerably less than that which is essential. The manner in which the crew survive could not be accepted in a commercial operation.

The CHAIRMAN. What about the passengers?

General QUESADA. You couldn't put them in a zoot-suit, sir, or a G-suit, or whatever you want to call it.

I am sure the passenger comfort has to be comparable in the supersonic airplane to that in a subsonic airplane. The public is not prepared to fly from Honolulu to New York in the discomfort that is essential to military operations to save 6 hours.

The CHAIRMAN. Nor are they prepared to wear a space helmet or anything of that sort.

General QUESADA. That is correct.

The CHAIRMAN. It is too suggestive of possible troubles, for one thing.

General QUESADA. The cabin has to be failproof in respect to ozone entrance. It has to be failproof in respect to its structural integrity which could result in decompression. Decompression at these altitudes carries with it life in the order of seconds of all passengers. They survive just a matter of seconds. Therefore, you just have to have a failproof cabin.

The CHAIRMAN. How high could you cruise in a supersonic plane and yet not be in an area where the failure of pressurization would take a person's life in a matter of seconds? For instance, the other day I flew to Los Angeles at 32,000 feet. That is not the altitude, is it, where human life is seriously jeopardized in the case of depressurization?

General QUESADA. If that airplane became depressurized you would have to descend at the most rapid rate possible. If this rate was not rapid, rapid to the extreme, serious damage would accompany the personnel.

The CHAIRMAN. Even at 32,000 feet that is the case?

General QUESADA. It is different to a degree. You can get down. There is no doubt about that. The airplane is capable of taking you down. But in the event of depressurization at 80,000 feet I will have to say to you very frankly you are hopeless. You have no possibility of getting down unless you have some outside aids that the public will not accept as normal.

The CHAIRMAN. General, I spoke to you before the hearing in reference to financing. How much would this program cost?

General QUESADA. Our program, our study, sir, has not advanced to a degree that would give you a reasonable or an accurate estimate of what it would cost. Purely as a "guesstimate" and nothing more than that, I am of the opinion that it would cost about $500 million. I think Paul Cherington, Dr. Cherington, might answer this.

The CHAIRMAN. Would you answer that question, please, Dr. Cherington?

Dr. CHERINGTON. It is hard to give any kind of definitive answer. Part of the cost of the development and production of these airplanes, including the development of the subsystems that would be required and so on, I think will turn on how much progress is made in programs like the B–70. So that if there is feed-in from the B–70 from a different but related supersonic transport this would tend to reduce the cost.

I would say essentially we are talking about a development and the production of some prototype aircraft which would cost in the vicinity of half a billion dollars.

The CHAIRMAN. $500 million?

Dr. CHERINGTON. Yes, sir.

The CHAIRMAN. I read into the record yesterday a letter from Continental Air——

General QUESADA. Mr. Bob Six, president of Continental Airlines.

The CHAIRMAN. Have you read the letter?

What do you think of his suggestion?

General QUESADA. I think his suggestion is constructive. I would hope it could be adopted over a broader field. I am not sure that everybody shares my view. But I have a very strong conviction, sir, that when the Government spends a large sum of money to develop a product all at its cost and that product eventually goes into commercial use, the Government should receive in return and to a reasonable extent what might be called a royalty. And be paid back some fair ratio of its contribution to commerce.

I think this is right. I practice it myself in my own Agency wherever and whenever I can. If we pay the cost of a computer and that company sells it to commerce, to a commercial user, it is our hope and it is our plan and intent that the commercial user will pay back to the Government a reasonable percentage of the development costs.

The CHAIRMAN. In other words, you would have, in effect, a sales tax on that particular airplane and that sales tax would be a return to the Government of a substantial portion, if not all, of the funds the Government had put out on it?

General QUESADA. It should return to the Government some ratio of its cost. I think you must attribute a reasonable ratio of the cost to that which is essential for military purposes. I do feel that it is right for the Government to get some return for its invested capital when it goes into commerce. And, sir, this is not new. The British have adopted this procedure. The British Government paid the cost of the development of the Viscount. The sale of the development of the Viscount throughout the world, I am informed, has returned to the English Government the costs that they incurred.

The CHAIRMAN. So they come out substantially whole on the development of the Viscount?

General QUESADA. Yes.

The CHAIRMAN. You would have the military make a contribution in accordance with the military value of the aircraft; then that would not be subject to tax. The value of the aircraft to commercial transportation, you feel, could be returned to the Government by a tax either out of profits or a sales tax on it?

General QUESADA. I would rather call it a royalty. Sales tax is kind of a bad word.

The CHAIRMAN. We all have taxes, even though we don't like them.

General QUESADA. I think this is right and fair. I think the industry will be better for it. I think it will stimulate industry. I think it will stimulate the aircraft industry in particular.

The CHAIRMAN. I have many more questions to ask you, General Quesada, but I am going to yield to the other members of the committee at this time.

Does anybody on the committee have any questions they want to ask? Mr. Fulton has a question.

Mr. FULTON. This poses the problem of what private industry does in the face of a revolution. Having been a corporation lawyer through most of my private life I am interested in how you accomplish the revolution. For example, I am interested in a good, successful airframe industry, aircraft engine industry, and airlines industry. Government regulation has practically ruined the railroads, hampered them, kept them from modernizing; kept them from developing and kept them on the verge of bankruptcy all the way through. I am a Republican Congressman but I have a firm feeling about it regardless of the stand of the administration. It appears to me this is the kind of policy which is on the straight road to monopoly and to chosen instruments, and to bankruptcy for almost every airframe company, aircraft engine company, as well as airline that is not one of the three or so big ones. There is something radically wrong when people go ahead and get a new type plane and the Government sits back and sits on its hands and watches difficulties occur in various airlines. There is something radically wrong when various airframe companies as well as engine companies are faced with tremendous unemployment, the destruction of their scientific teams, and tremendous losses in these times of great advances. There is something wrong in this industry, it seems to me, and tremendously wrong. The one thing that you have not mentioned in your statement is how we will keep a vital and healthy industry in the various air services along the lines that I have spoken.

The way it is working out is: It is going to mean a withering on the vine of the moderate-sized ones. It will end up with one or two tremendous systems having gobbled up everybody else. When these companies have to lay off their research people, these people have to get jobs, so they go to other companies. I think that is a tremendous challenge. It is a tremendous challenge for Government to do it through free enterprise. I can't see how any medium-sized airline company can survive that has bought planes and has to pay for them, and then gets into difficulty either with weather on routes or with passenger traffic at a particular time while they are paying off heavy capital expenditures and likewise heavy depreciation. I think there should be put in the record a statement, because to some of us in public life and some of us who have been connected with business, it becomes an intolerable

situation where we see the same situation going to occur on plane progress that has been occurring during these past years on the tremendous railroad industry. I want a healthy industry. I want it broadspread and I don't want it monopolized. I can't see from your testimony that it leads any other place but to bankruptcy and monopoly. It looks like it is going to be the same kind of thing in the aircraft industry and the airline industry that has happened to the railroad industry. I really don't want your comment on it, but I certainly hope that there is some soul searching and a look to see that something is done about the industry, not only of the companies but of the fine employees who have worked for these companies, and these research and development teams of scientists that are now being broken up in various airframe companies. I want some human interest put in it.

I have a question on the background information I have given. Do you agree that that is the kind of an approach that we need to this new horizon opening up in the aircraft and airframe, airline and engine industry? And secondly, do you have any specific plans on economics so that these matters can be accomplished through private enterprise on a broad basis without bankruptcies and destruction of scientific teams?

General QUESADA. As we indicated in the statement, we hadn't gone deeply into the economic implications of this particular program. You raised many points, and there is one to which I would like to add a hearty endorsement. I also am somewhat leery of the heavy hand of Government in private industry.

However, that must be accompanied by the assumption that industry must assume risk, and those industries that are in difficulty today, the aircraft industry, of which there are several——

Mr. FULTON. The airline industry.

General QUESADA. The airline industry is among them. They went into the business for profit, and in my opinion as soon as anybody goes into any industry for profit it must be accompanied by a reasonable risk.

The CHAIRMAN. And from the very first contract they had, which was way back, from the military, they have had dealings with support from the U.S. Government.

General QUESADA. In practically every case. I think it does fall upon the Federal Government to provide aid and comfort and advice and counsel wherever it is possible to do so in an industry as large and as vast as the broad aviation industry. It is one of the largest industries in the country. It requires a great deal of attention at this particular time. I assure you that within the bounds of good republicanism, which I am also, the administration's views are to encourage private enterprise to the absolute maximum extent possible. And if I may say so, not to encourage extreme socialism. As far as this particular program is concerned, I would hope that should it ever get off dead center, and I assume it will at some time, that the Government aid to it would only be to the extent that is absolutely essential and proven to be—not being able to accomplish through other means. I would hope that the aid could be broad. As I said in the statement, no one single company can do it. It would take a combination of many companies to do it. It is a very big task. So whereas I agree with the

principle that we should avoid the tendency of having one aircraft company survive the decade, I think this is a very important point that you raise, a very important point. But I would hope that the Government's participation in this program would be confined to that which has proven to be necessary and I think you feel the same way.

Mr. FULTON. Just in finishing—after what has happened in the railroad industry, and then to see this tremendous problem that faces the aircraft and airline industry, it certainly gives me the feeling that this is just where I came in, but in another industry. You see the same thing all over again.

General QUESADA. Well, I don't mean to be facetious, sir, this is the cycle through which all economies go. The stagecoach went through it. I think the aviation industry, its success in the future will depend to a large extent on its own vitality. I know it will survive. But it has to survive on its own merit. I do feel the less Government control that is exercised over it, the greater will be its probability of surviving the next century.

Mr. FULTON. I thoroughly agree with you on that.

The CHAIRMAN. Let me ask you this, General: Yesterday, General Haugen said he thought the supersonic transport was of vital importance to the military and to the security of our country with our far-flung bases all over the world. Do you agree with that? You have a very splendid military record behind you. I have confidence in your judgment.

General QUESADA. I think the military needs a supersonic transport.

The CHAIRMAN. Certainly you would say that commercial aviation needs one, too, wouldn't you?

General QUESADA. Providing it can be an economically feasible operation I would then say the commercial interests need it; and I think it can be economically feasible.

Mr. BASS. Why do we need, from a military standpoint, a supersonic transport?

General QUESADA. The only reason I can give at the moment, the main reason is time. It just saves time. Response can be faster. The movement to various places in the world can be faster. It should be presumed that we should always strive to increase reaction time.

The CHAIRMAN. Don't you agree that we have global commitments and that the quicker we can move personnel and supplies to the far-flung points of the globe, the better able we are to defend ourselves?

General QUESADA. That is true. And speaking philosophically, it would seem to me the Military Establishment should always strive to increase performance in all areas. It would be sad if the Military Establishment should ever become static. I think it has to progress in all areas.

The CHAIRMAN. I am as great a believer in private enterprise as anybody on this committee. I don't yield to anybody on that. But suppose the Soviets produce an operational supersonic aircraft such as we are now considering, and we don't have one; what would be the result, commercially and militarily?

General QUESADA. Speaking frankly, I think the result would be hysteria.

The CHAIRMAN. Similar to that of sputnik.

General QUESADA. Yes, and perhaps as irrational as to that of sputnik.

Mr. BASS. General, have you any positive evidence that the Soviets are going ahead in this field of developing supersonic——

General QUESADA. No, sir; I don't.

Mr. BASS. You spoke earlier about the justification for this program being a matter of national prestige. I am not talking about the military end, but the commercial end. I wonder if you could tell us in more detail just what is being done in other parts of the world?

General QUESADA. My comments in relation to national prestige were related to the position we hold, position of leadership throughout the world in the area of air transportation. It was very gratifying to me, and I am sure it would be to you, to be in Bangkok, where I was not too long ago, and find one American aircraft—aircraft of American design and manufacture—just pour into Bangkok one after another, in a remote area of the world, 27 foreign air carriers serve it, if I am not mistaken. This certainly enhances our prestige throughout the world. I think it influences our prestige to have American-flag carriers using American equipment migrating to all points of the world. In my opinion we should always attempt to improve this position. Certainly we should resist any degradation of it. It would seem to me that at some time in the future that a supersonic transport will be an accepted mode of transportation. However, I would personally deplore the idea of developing a supersonic transport just for fear that Russia might do it; I gag at that philosophy. But I do feel that a supersonic transport is a natural and normal extention of the state of the art. It has a relationship to the subsonic transport which is now the jet transport, the same relationship the jet did to the DC–3. I think it is inevitable over time that a supersonic transport will be developed by those who have an aeronautical capability. The companies of Europe are now to my certain knowledge attempting to get together and pool their resources to do it. But I only cite this as a natural evolution of events. To me this is not surprising. I would hate for us to just sit on our hands and do nothing.

The CHAIRMAN. While you have no information about the Soviet Union doing this, isn't it natural to expect the Soviets to attempt the same thing?

General QUESADA. To me, I must assume that they are. We are. We are developing a B–70. I think it would be unnatural to think that the Russians aren't doing it. But I have no positive information, do you?

Mr. SWIHART. No.

General QUESADA. I think it is a natural extension of the state of the art, and I don't think it should surprise any of us.

The CHAIRMAN. Whether it is financed one way or another makes no difference. Is it not a fact that thus far private enterprise has not been able to finance the program on the transport?

General QUESADA. Sir, I don't think that is quite right in the absolute sense that you mentioned it. The Douglas people financed, with their own money, the development of the DC–8. However, even that is subject to misunderstanding. The development of the engine was definitely a Government undertaking. The state of the art that permitted them to design with reasonable assurance a high performance jet transport embodying the internal structures that it must have,

with swept-back wings and so forth, a lot of that state of the art came from military programs which were hence Government sponsored. It isn't quite black and isn't quite white.

The CHAIRMAN. That was the next question that I was going to ask you. Is it preferable to wait on the B–70 program before taking up a supersonic jet transport program?

General QUESADA. I will attempt to make an answer to this, Mr. Chairman, but I wouldn't be surprised if I were proven wrong. So what I am trying to say is I am not sure of my ground here. It would seem to me that the program that the Military Establishment has got to develop a B–70 as a flight platform should go ahead, and it should go ahead with the same vigor that it has behind it now and it should not be retarded. It is going to give us, when I say us, the industry and the country, an answer to many, many questions that should be sought and obtained prior to going into the actual construction of a commercial airplane.

I think that the B–70 program should have ground into it commercial consideration. The Military Establishment is more than willing to do this. They are very willing. I would at this moment, sir, not be prepared to recommend a parallel development program for a commercial flight platform 1 year behind the B–70. I think the B–70 ought to go ahead and extract from it something like 80 percent or 75 percent of the requirements that are essential to a commercial program.

The CHAIRMAN. In other words, you think the Government through the development of the B–70 program ought to take up 80 percent of the cost of the development of the commercial air transport?

General QUESADA. Some order such as that, yes, sir, because it will make about 80 percent of the contribution.

The CHAIRMAN. It is as broad as it is long. If you develop the B–70 and it produces 80 percent of the solution of the transport problems; then the Government is really doing a good job for the transport program, too.

General QUESADA. It just can't be denied, sir. I don't think commerce can afford to pick up the bill of a parallel program.

The CHAIRMAN. Do you agree that 100 or 200 of these supersonic transports might be able to handle the world's long-range transport traffic?

General QUESADA. Dr. Cherington has some more accurate data on this.

Dr. CHERINGTON. Apparently from what we can see the market in the free world for this airplane, assuming a configuration with roughly 110 seats, is something in the order of 200 airplanes, if the cost, performance costs and hence the tariffs, fares that were depicted on that chart are approximately accurate.

General QUESADA. He has made a very thorough study of this.

The CHAIRMAN. In the event the United States decides to go ahead with the program, should we have two or more competing prototypes developed by different air companies?

General QUESADA. This would certainly be desirable, sir. But it would certainly be expensive.

The CHAIRMAN. Much more expensive than one single prototype.

General QUESADA. It would certainly be more expensive than a single prototype. However, I think that some of the objectives of

competing prototypes could be conceivably met by design competition rather than have them go ahead with the actual development of the unit. However, I must say even with a design competition I don't think anyone could assume the full responsibility. I think it would take several large companies to do it.

The CHAIRMAN. Assuming private enterprise cannot underwrite the development costs for a supersonic jet transport, would our air carriers as presently organized, be able to finance the purchase of operational transports of this character once they have been produced?

General QUESADA. I would suggest that you ask Mr. Tipton this question. He will be able to give a better answer than I can. He is head of the Air Transport Association. But at the moment they certainly could not. By the time this airplane comes along I would be inclined to think that some will be able to do so. I don't expect this to take place—for them to actually be confronted with this problem for 5 to 7 years at best.

The CHAIRMAN. In other words, we wouldn't have an airplane ready to be turned into an operational commercial aircraft for 5 to 7 years?

General QUESADA. At best.

The CHAIRMAN. That would be in your opinion a development from the B–70 program?

General QUESADA. The B–70 will contribute a major share to a commercial supersonic transport if it is eventually considered feasible.

The CHAIRMAN. If you had only one prototype would that tend to destroy the competitive spirit in industry?

General QUESADA. I think it would tend to; yes, sir. I think it would do just what has been suggested.

Mr. FULTON. That is my point.

The CHAIRMAN. Then if you have more than one to give the competitive spirit to industry, it would cost us so much more?

General QUESADA. It would cost you so much more. The only possible source of the investment is the Government. Then you are moving into socialism. It is a dilemma.

The CHAIRMAN. Then it is either take one, or move into socialism?

General QUESADA. To some extent. I want to say again, if I may, that I don't think it is reasonable to expect that one company can do this, do you, Paul?

Dr. CHERINGTON. I would guess it would be some kind of a team.

The CHAIRMAN. Is it possible that the industry might be so organized under law, or perhaps voluntarily to get together on a program to develop the jet supersonic transport?

General QUESADA. That wouldn't be new, sir. That is done today. Various segments of the industry often get together and perform as a team to proceed on significant and large military programs.

The CHAIRMAN. How much money would they have to raise to work that out?

General QUESADA. Any amount I would say now would be very meaningless. I don't know nor does anyone else.

The CHAIRMAN. It would be a considerable sum?

General QUESADA. Yes.

The CHAIRMAN. The United States would have to make a contribution to the program?

General QUESADA. It could even to a specific program and it is doing so in the B–70 program. It could do it outside of that.

The CHAIRMAN. Then the private industry would be given the job of developing the jet supersonic transport?

General QUESADA. It should. I would hope that the Government would never be given the responsibility of developing a supersonic transport.

The CHAIRMAN. Like the building of the *Constitution*, the United States made a contribution to the construction but the ship was built by private industry. A similar sort of program?

General QUESADA. That is correct.

The CHAIRMAN. Then industry would be able to have available this type of plane and the Government could also have available the same type of plane for its military and peacetime needs?

General QUESADA. That is correct.

The CHAIRMAN. Counsel has asked me to pursue this: One witness has testified that there should be a national program to develop a supersonic transport. What role should the various agencies play? Which agency should manage such a program?

General QUESADA. Certainly the Military Establishment should manage the military program. I don't think there is any doubt about that. They will be the largest contributor to a supersonic transport.

The CHAIRMAN. You would have it under the military?

General QUESADA. No, sir; not the development of a commercial transport, I wouldn't.

The CHAIRMAN. It would not be under the military, but the military would be the largest contributor?

General QUESADA. That is correct. I wouldn't have the executive management of the development of a supersonic transport for commerce purposes in the Military Establishment. I definitely would not.

The CHAIRMAN. Where would you put it, under NASA?

General QUESADA. I don't think so. I don't think NASA would want it; would you?

The CHAIRMAN. Who would want it?

General QUESADA. By the law I am forced into this position. I don't like it, but by the law this is our job.

I would have to call on other agencies obviously to provide various types of guidance. Mind you, I am referring now to a commercial supersonic transport.

The CHAIRMAN. Development of a prototype is a scientific project, and that is the reason why I would suggest NASA. Once we have developed the prototype and get into regular production, of course, undoubtedly it would be under your Agency.

General QUESADA. Sir, I think that this would be a departure that NASA would find somewhat objectionable. And I do. Because I don't think the Government should get into this business. NASA could design, could develop, test, and fly this airplane very, very well. But I think this is an improper role for any Government agency. I think industry should do this.

The CHAIRMAN. You don't refer now to the Federal Aviation Agency, do you?

General QUESADA. I don't think we should design this airplane.

The CHAIRMAN. You don't think you should design it, but you think you should coordinate the efforts of Government?

General QUESADA. That is correct.

The CHAIRMAN. Then when it is produced, industry would handle the program, of course.

General QUESADA. Definitely. Absolutely under no circumstances in my opinion should the Government ever get into the design and construction of aircraft.

Mr. MOELLER. I would like to ask the general if he has a developmental team for such a project, or would you have to acquire such a team?

General QUESADA. That is the point I am trying to make. I don't think any Government agency should have a development team to design an airplane such as this kind.

Mr. MOELLER. Even for the coordination, you would certainly require some very topnotch people, technical people to coordinate the program; would you not?

General QUESADA. We have that. I wouldn't say that we have the best in the world. We are working with the Air Force right now on the specifications essential to a modern cargo airplane that is adaptable to military and civil use. The interplay between us has caused a common specification to be written.

I think this is the limit and the extent to which both the Air Force and ourselves should go—to write the specifications and then tax the ingenuity of industry to meet them and exceed them. This is really the point I am trying to make. We should confine ourselves to the preparation of real specifications and imaginative specifications that industry should meet, whereas NASA can meet them. NASA can design this airplane very, very well.

Mr. MCDONOUGH. General, as I understand it, you don't believe you should do the basic research or do anything about the experimental design of this supersonic plane?

General QUESADA. I believe we should not.

Mr. MCDONOUGH. That is what I say. However, do I understand you to say that once it is designed and put into operation and made practical, then it would be your responsibility to direct its traffic, to control its flights, to set up specifications for its operation?

General QUESADA. That is in the law already. We have to do that.

Mr. MCDONOUGH. There is no question in your mind about that?

General QUESADA. No question whatsoever.

Mr. MCDONOUGH. You think if you should prepare specifications, private industry should follow in the attempt to produce it?

General QUESADA. I think the Government should only prepare specifications for an airplane when Government money is being used to develop it. Let's take the DC–8. The Government didn't prepare the specifications for that airplane. I don't think they should. The Douglas Aircraft Co. developed—wrote the specifications at its own risk and with its own money, and they should have the right to do so, but the Government, if it is going to go into a support program and support the development of this airplane, I think it is proper for the specifications to at least in the broader sense emanate from Government sources.

If that airplane is for a commercial purpose, to go into air commerce, there is no doubt in my mind but what the law provides for the Federal Aviation Agency performing that function.

Mr. McDONOUGH. In your opinion of this supersonic type of plane for commercial purposes, do you think that its experimental development and the cost in making it a practical operation unit is too expensive for private industry? Should the Government support any facet of the development?

General QUESADA. Sir, at the moment my opinion is that there is no one company that could assume the risk. I have grave doubts whether any combination of companies could assume the risk, and thence if it is to our national interest to have this airplane developed and there is no other source from which capital can come, it only leaves the Federal Government.

I feel that at some time the Federal Government might have to make a significant contribution to the development of a supersonic commercial aircraft.

Mr. McDONOUGH. Do you see any practical military benefit in this type of plane within the near future or at the present time?

General QUESADA. I see practical benefits of a supersonic bomber to the Military Establishment, which they have now.

Mr. McDONOUGH. Equal to the one that we are talking about?

General QUESADA. No. I see some military benefits.

Mr. McDONOUGH. It would be to the benefit of the United States to develop it for part of our military posture.

General QUESADA. In my opinion that is what they are doing.

Mr. McDONOUGH. As a result of making that practical, it would eventually become useful for commercial purposes?

General QUESADA. The state of the art that would be developed, to a large extent, would become useful for commercial purposes.

Mr. McDONOUGH. This is a far cry from the old Question Mark which you first made your reputation on in San Fernando Valley.

General QUESADA. A very far cry.

Mr. McDONOUGH. I was there at the time and saw you depart from the plane after the experience you and Touhey Spaats had.

General QUESADA. I am surprised that you were old enough to be permitted to go to the airport, sir.

Mr. McDONOUGH. That was quite a feat. What was it? 155 hours in the air?

General QUESADA. About a week.

Mr. McDONOUGH. You fueled by hand from another plane and you were showered by gasoline many, many times.

General QUESADA. We grabbed the hose in our hand and dumped it into a funnel.

The CHAIRMAN. We have gone a far cry from that.

General QUESADA. Yes, and we will go as far in the future. This is the point I am making. The difference between now and the future is no greater than now to the past.

The CHAIRMAN. We may ask you to come back at some later time General, because you have so much valuable information and there are so many questions that we would like to ask you. However, we have other witnesses. So to sum up, is it to our present national interest to proceed with such a program as this?

General QUESADA. In my opinion it is to our national interest to proceed, and I had hoped the procedure would be orderly, would progress as the state of the art progresses, would move the state of

the art forward and we wouldn't respond to hysteria. It is a very, very difficult program. It is technically complex. The B–70 program that is now contemplated and designed is going to be a tremendous contribution to what your objectives are.

I think the thing we have to cope with is to be sure that the B–70 program progresses and that it is not retarded. That is what I think now.

The CHAIRMAN. We certainly want to have a plane of this sort developed before the Soviets do.

General QUESADA. Definitely.

The CHAIRMAN. Would you outline, for the record, just what specific things should be done?

You say that it is to our national interest to have such a program. Specifically what should we do and in what order should we take these measures? You can take your time. Give it to us for the record.

General QUESADA. I feel your committee, among other things, should continue its interests. I feel that the B–70 program should carry on and that every encouragement to it should be given. It is a very imaginative program. It is the key to progress in this area. Without the B–70 program, sir, I think the development of a supersonic commercial transport is hopeless. I don't think there is any possibility of developing a supersonic transport without the continuation of the B–70 program generally along the lines that are now contemplated.

As this program goes on and as some of these unanswered questions are revealed and valuable information is gathered from it, we have to early start grinding into the B–70 program the commercial requirements and commercial considerations.

I judge your interest is in the commercial transport, so the agency such as ours must continue its effort. It must try to bring into commerce with the least possible delay the benefits that the B–70 program reveal.

The NASA is certainly not uninterested in this program through research, basic research or the most far-reaching research, agencies like the NASA are giving to us answers to questions that even the B–70 program won't reveal. They are doing some very, very profound research in this area. This must be continued.

The CHAIRMAN. Basic research?

General QUESADA. Yes, sir. Very basic. Their effort is very essential. As the program goes on, we have to take an increasing interest and an increasing direction of it.

Mr. MCDONOUGH. General, do you think the X–15 is a first step in this direction? Here is a type of plane that is designed for supersonic flying, for high speed——

General QUESADA. Hypersonic. Your point is well taken, sir.

Mr. MCDONOUGH. Its configuration is designed for high-speed flying. It has a heat resistant skin in order to prevent overheating. These are steps in the direction of this——

General QUESADA. Definitely.

Mr. MCDONOUGH. We are moving in that direction. Of course, now, as far as we know, the only propellent for this kind of plane is rocket propulsion, for the supersonic.

General QUESADA. For the mach 3——

Mr. SWIHART. The mach 3 airplane would be a regular airplane as we know it now, an air-breathing engine.

The CHAIRMAN. It would use kerosene-type fuel?

Mr. SWIHART. Yes.

General QUESADA. If you go up to a mach number of 10, then you can get into a ramjet engine. Ten and above you get into another type of engine.

Mr. SWIHART. You get into a ramjet engine along about mach No. 4 or 5 and this ramjet engine could logically carry you to 10.

Mr. MCDONOUGH. What is the maximum speed we can anticipate with an air-breathing engine in hypersonic areas?

Mr. SWIHART. I would assume that with logical development of the state of the art, and this is a long time away, that we could probably fly at hypersonic speeds with an air-breathing engine up to mach No. 8 or 10. We could certainly fly at mach No. 6 or 7.

Mr. MCDONOUGH. At the present time we don't anticipate much need for flying any faster?

Mr. SWIHART. Not in the atmosphere.

Mr. MCDONOUGH. Because you have a heat problem there?

Mr. SWIHART. Yes.

Mr. MCDONOUGH. You have the problem from where you want to go and what you want to get to in such a short space of time. You could go a couple of times around the world at that speed.

The CHAIRMAN. What would you say would be the optimum speed for commercial supersonic jets?

Mr. SWIHART. For the kind of trips that we are talking about, transcontinental and transoceanic and perhaps even as long as the New York to Honolulu trip, I would say that we are talking about speeds somewhere in the region of mach numbers of around 3.

The CHAIRMAN. Which is 2,000 miles an hour.

Mr. SWIHART. Yes.

The CHAIRMAN. What would you say would be the optimum speed for military aircraft?

Mr. SWIHART. I would say on this same trip about the same.

The CHAIRMAN. Fightercraft or bombers?

Mr. SWIHART. The B–70.

The CHAIRMAN. I was briefed by you about a year ago down at Langley. I think they said at that time the optimum speed for military aircraft might be pushed up to 3,000 miles an hour.

Mr. SWIHART. This would be for a little longer trip, sir. In a longer trip I think you could take that chart of trip time that I had for New York to Paris; for a longer trip you would want to push the speed up to higher values.

The CHAIRMAN. 3,000 miles?

Mr. SWIHART. I want the committee to understand that the remarks that he made were not glib. These are the products of very extensive study. As you go beyond three you assume other penalties. So all this is the product of a very thorough and long, drawn-out study which comes out, if you want to go above 3,500 miles, mach 3 is your optimum area. If you want to go 8,000 miles, perhaps some other speed is optimum. When you go 8,000 miles, then you assume other penalties.

All of these put together come down with an optimum area around three and 3,500 miles and the course that we have referred to.

The CHAIRMAN. Is mach 3, 3,500 or 2,000?

General QUESADA. Around 2,000.

The CHAIRMAN. Any further questions from the members?

Mr. Hammill is the committee counsel. Would you like to ask any questions, Mr. Hammill?

Mr. HAMMILL. I have no questions, Mr. Chairman.

The CHAIRMAN. We could ask many more questions, but we must get on to the next witness. General Quesada is a man with a good disposition and if we ask him to come back, I am sure he will.

General QUESADA. I would be glad to.

The CHAIRMAN. Thank you for a very informative statement and for the help that you have given. I was briefed about a year ago by NASA on these matters. I know they have made extensive studies and their statements are not glib.

Mr. MCDONOUGH. Just one question before the general leaves.

I suppose you keep current on the X–15 flights?

General QUESADA. Reasonably current, sir. I am not an expert on it by any means. I don't know every detail.

Mr. MCDONOUGH. Are you satisfied that we are making progress in that particular type of operation?

General QUESADA. I am satisfied that reasonable progress is being made. Any time you go into a large step of progress such as this program entails, you are going to be accompanied by temporary frustrations. We have learned not to be surprised by them—or frustrated, I perhaps also should say. The program is getting along quite well. It is going to give to us a great deal of data that is going to be helpful not only in the advancement of weaponry, but also in commerce, too.

The CHAIRMAN. We thank you, General, and all of your group, for coming this morning.

General QUESADA. Thank you so much.

The CHAIRMAN. At this time we will hear Mr. John Adams. He is Associate Director, Legal and Planning, of the Bureau of Air Operations, Civil Aeronautics Board. Mr. Adams.

STATEMENT OF JOHN ADAMS, ASSOCIATE DIRECTOR, LEGAL AND PLANNING, BUREAU OF AIR OPERATIONS, CIVIL AERONAUTICS BOARD

Mr. ADAMS. Mr. Chairman, the Civil Aeronautics Board appreciates the opportunity to appear before your committee and discuss with you certain phases of the prospective development of a supersonic transport for commercial uses.

As I am sure you gentlemen are aware, the Board's interest in the development of any aircraft with potential commercial uses is chiefly an economic one, and directs itself to the impact of such an airplane on the civil air transport system of the United States. Consequently, our discussions here will be primarily related to the economic problems which would accompany the introduction of this new type aircraft into the civil air transport industry.

The Board wishes to make clear at the outset that we believe that the supersonic transport aircraft certainly is going to be developed, and certainly is going to appear on the commercial airlanes of the world, most likely within the next decade. Its coming will cause problems, some of which I will discuss today, but none of them of such consequence that we should lose sight of the overriding necessity that such an aircraft be of American design and manufacture. If our country were to stand by and permit another country to step into the American position of prominence in the field of aircraft manufacture, it would be a tremendous blow both to the prestige and the economic stability of the American aircraft manufacturing industry.

While the Board cannot forecast the exact specifications of the supersonic transport of the future, a few points about such an airplane should be of interest. Economic studies made by various American manufacturers and presented separately by their representatives to the Board in the past few months indicate that if the supersonic transport comes into being within the next decade, because of its limited use potential due to its confinement to long haul routes as well as because of its tremendous performance capability, the entire requirement of all of the air carriers of the world probably can be met by the manufacture of between 100 and 200 of such airplanes.

Most manufacturers think that such an airplane for commercial use would travel at about 2,000 miles an hour, carry between 80 and 160 passengers, and would make travel to such points as Rome, Paris, or Frankfurt a matter of about 2 hours elapsed time.

The economic cruising altitude would require the aircraft to fly so high—55,000 to 75,000 feet—that economic utilization would be improbable at distances less than 1,200 to 1,800 miles. Consequently, carriers serving essentially medium haul routes probably would not be able economically to use the aircraft.

The tremendous speed of the aircraft, if accompanied by proper navigational aids and ground handling equipment, would be such that airlines with long distance routes could operate those routes with about one-third of the equipment needed to operate with current jet equipment.

The high cost of the aircraft—estimated at between $12 and $25 million—together with its tremendous capabilities could very well mean that many carriers would have to utilize interchange agreements in order to get sufficient utilization to warrant the investment.

Its cost can only be projected in the most general terms, and figures ranging from $250 million to $1 billion as an initial development cost are heard, and individual unit costs of $12 million to $25 million are regularly discussed. A performance capability at least three times as great as that of our current jets is regularly forecast for it. What such an airplane will mean to the civil air transportation industry from an economic point of view is tremendous, and obviously is of great concern to the Civil Aeronautics Board because of our responsibilities for the economic stability of the civil air transport industry.

In the Board's short lifetime the industry has progressed through various types of equipment. First was the DC–3, carrying 21 passengers and flying at a speed of 160 to 180 miles per hour, then the DC–4, the DC–6 and DC–7, and the Constellation. The life of these aircraft was remarkably long. The DC–3 and the DC–4 appeared

before the war and are still doing creditable service in some areas of our commercial air system.

The Constellation and the large Douglas airplanes appeared just at the end of the war and until very recently were the backbone of the long haul operations of most of the air carriers of the world. They lasted as first line airplanes for nearly 15 years.

The achievements of these aircraft are now being overshadowed by various types of turbine powered equipment which have appeared in recent years. First was the turboprop and most recently the pure jets. The impact of the advent of the pure jet aircraft on the commercial air transport system of the world has been tremendous.

Carriers on the long haul routes who were at a delivery disadvantage found themselves suffering tremendous losses of traffic to these high speed aircraft which fly in the neighborhood of 550 miles an hour and offer comfortable and luxurious transportation hardly anticipated so recently as the end of the war. The effort by the long haul operators all over the world to move from piston aircraft to jets has been a vigorous one. Current jet acquisition programs suggest that in a short period of time piston aircraft operating on the competitive long haul routes will virtually disappear.

The result of this transition shows in many ways, one of the most striking of which is the tremendous surplus of used piston aircraft now appearing in the inventory of the air transport industry. Carriers who are purchasing jets are searching for means either to utilize the piston aircraft or to get them transferred out of their system on satisfactory financial terms. Resale is becoming a problem, and all indications are that the problem will increase.

Even so, the carriers are discovering that it will be cheaper in the long run to put the piston fleet in mothballs in order to convert to jets. While to do this is costly, it can only be imagined how much more costly it would be had it been necessary for the carriers, for competitive reasons, to buy these jets before an extended period of use had permitted them largely to amortize their investments in piston-type aircraft.

The same financial problem must be considered when one contemplates the emergence of the supersonic transport. If such a transport were to be ready for delivery in the next 2 or 3 years, its competitive impact would be such as to force its acquisition by most of the long-haul operators.

For example, if a European manufacturer were to build such an aircraft and sell it to any foreign carrier operating across the North Atlantic, and if this carrier could then offer Paris-New York service in less than 2 hours with equal cost, comfort and safety assurances as the transatlantic carriers presently can offer in the jets, it is quite obvious that in a short period of time all competitive carriers, foreign and American, would be forced to acquire this aircraft even though their jet fleets were not fully amortized.

Statements have recently appeared in various news media suggesting that the development of a supersonic transport may be going forward at the present time in Britain, Russia, and France.

On January 18, 1960, the Aviation Daily, a widely read trade paper, indicated that the British Minister of Aviation, Mr. Duncan Sandys, favors British Government support of their aviation industry in the field of supersonic development.

The Washington Post on January 15, 1960, quoted Andrei N. Tupelov, father of the Soviet TU aircraft series, as saying in a speech to the Supreme Soviet that a new supersonic transport is being developed in Russia.

Further, the May 5, 1960, issue of Aviation Week, another trade magazine, carries a story with a Paris dateline describing the cooperative development venture by two French manufacturers designed to put a supersonic medium range airliner in the air.

While recognizing the financial problems and potential danger to our carriers of too early an emergence of a supersonic transport aircraft, we must not ignore the potential effect on our manufacturing industry of the possible successful development of such an aircraft elsewhere in the world. American manufacturers feel that the foreign manufacturers are targeting for an operating supersonic transport somewhere between 1965 and 1968. In fact, in the press notice referred to above concerning the French program, French sources speak of an operating aircraft in 1964. If this is so, then America must move and rather soon.

One American manufacturer estimates that, given adequate financial assurances, he could have a prototype flying in about 3 years, and following extensive flight testing, could make deliveries in another 3 years of so. Assuming, therefore, that an American manufacturer were to start development sometime in 1960 or 1961, the first aircraft probably could be delivered into the commercial system by about 1967 or 1968.

Exactly how we should move to assure such a result is not entirely clear. With estimates of the cost of development of such an aircraft ranging from $250 million to $1 billion it is obvious that full financing is beyond the capability of one carrier, or even of many private carriers acting in concert. Indications from abroad are that each of the foreign countries interested in the project—Great Britain, Russia, and France—expect the program to be government financed. Most probably the same thing in some form will be necessary in the United States.

All four large American manufacturers of commercial transport aircraft, Boeing, Convair, Douglas, and Lockheed, tell the Board that they have spent considerable time, effort, and money in studies of the supersonic transport aircraft, and obviously any one of them would be capable of manufacturing such an aircraft given proper financial encouragement. Also, North American Aviation, in its work on various military programs, has spent a tremendous amount of time and money in the development of supersonic military aircraft.

Manufacturers to whom Board representatives have talked speculate that no manufacturer could build the aircraft without initial orders for between 40 and 80 aircraft, and most of them assume that in order to be profitable, whichever manufacturer gets the initial order probably will have to manufacture all of the aircraft which are built, although some concede that perhaps two manufacturers, each capturing about half the business, might build the aircraft profitably.

The United States has already taken some initial steps in the supersonic field, in its investment in the B-70 program. While the future of this program is far from settled upon, it gives us our best clues as to the possibilities in this field of development. One thing this pro-

gram has so far developed is that a supersonic transport is technically feasible.

It remains to be decided whether the Air Force will be authorized to proceed with the full development of the B–70 bomber, which could be the pattern plane from which the commercial supersonic transport might be developed. Because the potential of a supersonic transport appears to be at least as great from a military as from a commercial standpoint, we believe that a good way of assuring its development is for the Government to go forward with development of a military aircraft such as the B–70. This, of course, is not the only solution. There may be other approaches which are logical and which are financially attainable. While the Board was not aware of them at the time of the preparation of this statement, if they prove to be of merit, naturally they would have Board approval and support.

The CHAIRMAN. We certainly thank you for your statement. I regret to say that we are going to have to quit promptly at noon today. I would like to ask you this:

You link the development of this program up with the development of the B–70 program?

Mr. ADAMS. Yes, sir.

The CHAIRMAN. You also indicate in effect, unless someone steps in and orders it differently, the result of developing this type of plane will result, as Mr. Fulton has said, in a monopoly?

Mr. ADAMS. I indicated that?

The CHAIRMAN. Yes, sir, in your statement. I will read this, where you say that—

> Manufacturers to whom Board representatives have talked speculate that no manufacturer could build the aircraft without initial orders for between 40 and 80 aircraft, and most of them assume that in order to be profitable, whichever manufacturer gets the initial order probably will have to manufacture all of the aircraft which are built * * *

That gives that aircraft company a monopoly.

Mr. ADAMS. It would give that company a monopoly on the manufacture of that particular airplane. I think if the pattern of what has been happening in the construction of other aircraft is an example, one company would not do it alone, however. For instance, North American, in the B–70 program, is getting a great deal of help from other aircraft manufacturers who are doing parts of it. I think Boeing, in its 707 program, while it is delivering the end jet, is subcontracting an enormous amount of work to other people in the industry. You might have the monopoly on the name of the airplane at the end, but there would be a tremendous amount of support from other people in the industry.

The CHAIRMAN. In other words, by agreement or by proper organization all could contribute to the program.

Mr. ADAMS. All would have to contribute.

Mr. MOELLER. Mr. Adams, I am wondering if you have given any thought to this: Could this possibly be a cooperative effort on the part of not only the United States, but let us say France and England? Why do each of us have to make one? Could we possibly let England or France make them and we buy them from them and have the same end result which would naturally be much, much cheaper?

Mr. ADAMS. These things are always possible.

Mr. MOELLER. Could there be a cooperative effort of say the three great powers of the free world?

Mr. ADAMS. There is no reason why cooperative effort of that sort couldn't be accomplished.

Mr. MOELLER. It could be considered cheaper.

The CHAIRMAN. I'm sorry, but we are going to have to adjourn now. I am very sorry, sir, because we would like to pursue the matter a little further with you. We are expected on the floor. There is quite a fight coming up.

Mr. Stuart G. Tipton, president of the Air Transport Association of America was to be our next witness.

We have a full committee meeting scheduled tomorrow morning at 10 o'clock. We should finish with our business very soon thereafter. Could we hear you at 11 tomorrow?

Mr. TIPTON. I will meet the committee's convenience, Mr. Chairman.

The CHAIRMAN. Normally we would meet this afternoon, but there is going to be a fight on the floor of the House, and we must all be there.

Mr. TIPTON. I will turn up at 11 o'clock in the morning right here.

The CHAIRMAN. Thank you.

The subcommittee is adjourned until 11 o'clock tomorrow and the full committee at 10 o'clock.

(Whereupon, at 11:50 a.m., the subcommittee was adjourned, to reconvene at 11 a.m., Thursday, May 19, 1960.)

SUPERSONIC AIR TRANSPORTS

THURSDAY, MAY 19, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SPECIAL INVESTIGATING SUBCOMMITTEE,
Washington, D.C.

The subcommittee met at 11 a.m., Hon. Overton Brooks (chairman), presiding.

The CHAIRMAN. The committee will come to order.

Our witness this morning is Stuart G. Tipton, president of the Air Transport Association of America.

Mr. Tipton has a prepared statement.

We will appreciate your proceeding with your statement.

STATEMENT OF STUART G. TIPTON, PRESIDENT; ACCOMPANIED BY WILLIAM BECKER, DIRECTOR OF OPERATIONS AND ENGINEERING, AIR TRANSPORT ASSOCIATION OF AMERICA

Mr. TIPTON. Thank you, Mr. Chairman and members of the committee.

The Air Transport Association, of which I am president, is made up of all or virtually all of the certificated scheduled airlines of the United States, both domestic and international.

It is a tribute to this committee's foresight that you have scheduled these hearings on the feasibility of a supersonic transport, and we appreciate this opportunity to state the airlines' views.

In a sense, it is probably fruitless to speculate whether a supersonic transport should be built. The whole history of transportation indicates that it will be built. Just as the railway and the motor vehicle replaced the stage coach, and for the same reason that our current high-speed, long-range aircraft overshadows the ship, man will doubtlessly take the next step toward whatever is better transportation. As one leading aviation engineer expreses it:

> The whole history of Western technology represents a single coherent development, in which each revolutionary breakthrough leads to continued evolution * * * there can be no doubt that the supersonic commercial transport will come.

Supersonic air transportation appears as the next logical step in satisfying man's natural desire to travel from one place to another in the least possible time. It is reasonable to assume that a supersonic transport will emerge as quickly as the basic requirements of safety, comfort, and cost are met.

The question is whether the United States should take the lead in the development of such a transport. Already, it has been announced that the United Kingdom has let study contracts for the design and

development of a supersonic transport. With their long history of aviation leadership and accomplishment in the design and development of the Comet jet, it is not surprising to find the United Kingdom again pointing toward the lead in the development of new transport aircraft. There are reports of French and West German cooperation in further developments of aircraft in the production of which they are now already collaborating. Similarly, we have reports of Soviet Russia's entry into the design phase of a supersonic transport.

The United States has traditionally maintained world leadership in aviation and there appears no sound reason why we should relinquish it. In fact, in the kind of world in which we now live, there is a special importance in maintaining such leadership. Whether we can maintain it without developing a supersonic transport seems doubtful. This much is clear: Leadership in the introduction of supersonic air transportation will bring great national prestige to the nation first in the field. In a study for the Department of Defense, in fact, the Rand Corp. concluded that national prestige is the primary consideration in determining whether this Nation should develop a supersonic transport.

True, to the best of our knowledge, there is as yet no actual supersonic transport type aircraft in existence—even as a design. But we are told by reputable engineering authorities that we have the know-how in our present grasp, and that no technical breakthrough in the state of the art is required to produce such an aircraft. The estimates as to how soon such an aircraft would be placed into actual operation vary—from 1965 to the early 1970's. But there is no one, to my knowledge, who says that it cannot be developed.

If some other nation gains leadership in aviation by pioneering supersonic air transportation, it is a foregone conclusion that the United States would be required to catch up. And as one aviation leader has expressed it:

> It is probable that it would cost no more to be the leader in the introduction of supersonic air transportation than to "catch up" at some later date.

Why must we decide now? The answer lies in the complexity of the design and construction of modern aircraft, which demands that preliminary studies be commenced many years in advance.

In addition to the complex aircraft design problems, there are extensive complementary studies which would have to be carried out concurrently to insure the safe and efficient operation of such aircraft, such as: new air traffic control systems and procedures, high-altitude meteorological techniques, improved border-crossing regulations, navigational and positioning developments, medical and psychological techniques, rapid communications, and data processing, automatic computer and other automation development. These problems are highly complex and in many cases controversial. Still, it is vital that they be worked out at the same time the aircraft is under development. If this is not done, we might have the aircraft, and not have the operational and economic means and methods to use it.

To build a supersonic transport will cost a great deal of money. The estimates range from an improbable low of $75 million to more than $1 billion. These estimates, moreover, are for the aircraft/

alone. The development of all the complementary and related operational facilities will doubtlessly cost many millions more.

Whatever amount in this range is correct, it is clear that neither the manufacturers nor the airlines are able to finance such an undertaking. If the machine is built in England, it would have to be supported and sponsored by the British Government. If it should be built in Russia, it would be the direct responsibility of the Soviet Government. And if it is to be built in the United States, then the United States must be behind the project, and it will have to be justified and authorized on the basis of the national interest. Clearly, whoever does build a good supersonic transport will be in a position to dominate the air routes of the world and its factories will have an unchallenged product for export. The transportation services of the world will be revolutionized.

Our best guide to the capability of a commercial supersonic transport is to be found in the design and performance specifications of the U.S. B–70 supersonic bomber. While much of our present knowledge of supersonic speeds is derived from the development of the B–58 bomber, the B–70 represents the first attempt to give a large airplane a speed potential of mach 3—three times the speed of sound.

The cruising speed of the B–70 is to be 2,000 miles per hour—approximately four times as fast as our current jets. It is designed to fly nonstop for 7,000 miles, and from existing bases could reach any part of the world in 6 hours with a payload of some 20 tons. A commercial supersonic transport might be a smaller and lighter airplane, and somewhat slower. Even so, it should cross the Atlantic or cross the United States in about 2 hours. With a comparable payload, it should be able to carry up to 200 passengers.

At this moment, it is not clear whether the B–70 program will go forward. As of now, a single prototype has been authorized, but there has been a stretchout in the B–70 program which will have a definite effect on the development of a commercial supersonic craft. If the Congress decides that our national policy requires the development of a supersonic transport, then it would be hoped that it would appropriate the necessary funds to complete the B–70 program. For, although admittedly there is no direct relationship between the development of military bombers and commercial airliners, the contribution of the military forerunner is a substantial one. The development of existing types of bombers brought about a significant advancement of the art in the case of our present jets—enough to enable 600-mile-per-hour operation.

The jump to 2,000 miles per hour is quite a jump. It is, in fact, an entry into what has heretofore been an unproven area of aeronautical advancement. There are, nevertheless, many reasons for believing that it can be done. The task will not be an easy one. The gap between saying no breakthrough is required and successfully flying a supersonic transport is a wide one.

Certainly we should make no decision until all of the relevant facts have been explored. This in itself will be a monumental undertaking. A great deal has already been done, in the B–58 and B–70 programs, and in independent appraisals by manufacturers.

All of the leading U.S. manufacturers of civil transports are seriously working on long-term plans for supersonic commercial

transport. One of them reportedly has already evaluated more than 100,000 design parameters in electronic computers; another has reportedly spent more than $1 million in wind tunnel research to develop the most promising configuration. But this is merely scratching the surface. It has been estimated that more than 15 million man-hours will be required to develop the aircraft itself, not to mention complementary ground and traffic facilities and the myriad aids which will be required by so revolutionary a machine.

Substantial research will be required in special areas. For example, one of the physiological problems of operation at altitudes as high as 60,000 to 80,000 feet is the encountering of cosmic radiation and ozone. From the airlines' point of view, a great deal more will have to be done in the way of economic analysis before it is known whether the aircraft will fit their financial ability and operational requirements.

These things can and should be done. But they must be done in an organized and intelligent approach to avoid a veritable chaos in air transportation. We are still in the throes of a difficult transition to our present jets. During a time when the airlines have needed every Government encouragement, we have witnessed indecision and conflicting policies of Government agencies. Through more than 4 very difficult years, the Civil Aeronautics Board consistently refused the moderate fare increases necessary to secure adequate airline financing for the jets. The State Department meanwhile contributed unjustified competition from foreign carriers—laying down foreign route after foreign route over the backs of U.S. flag carriers, until our share of the transatlantic travel market declined from nearly 70 percent to less than 38 percent.

While the airlines were struggling to accomplish the greatest single equipment revolution in any industry in the history of the world, the Defense Department expanded its own competitive airline—MATS, virtually duplicating the routes of the U.S. flag carriers.

In the vital areas of airspace management, control procedures were left to struggle along in conflicts between the CAA and the military until Congress finally resolved the situation by establishing the Federal Aviation Agency.

On top of it all, the Treasury Department fought to maintain the oppressive 10 percent "wartime emergency" travel tax—to make it all the harder for the airlines to carry out a courageous private enterprise advancement.

There is no question but that the jet revolution was rendered immeasurably more difficult by confused, indecisive, and often crippling Government policies.

To make a successful transition to supersonic aircraft, we should not suffer such indecisions and conflicts. The factors which will determine whether the supersonic transport will or will not be economically feasible must be analyzed in advance and necessary policies established before the aircraft is ever constructed. Otherwise, it is almost doomed to failure.

To this end, we believe that the only way in which all of the diverse interests and possibly conflicting policies may be brought into focus and resolved would be to assign the job to a single Federal agency, presumably the FAA, and to provide for the creation of a combined legislative and executive commission to guide the work of that agency.

The task of the Commission would be to define the problems, accumulate the facts, and make policy recommendations to resolve the problems prior to the time the aircraft is introduced.

We are encouraged to see that Congress and this committee have recognized the importance of the question of developing a supersonic transport. We would hope, in the interest of U.S. leadership in aviation, and for the sake of the prestige and economy of our Nation that the decision will be made, and made quickly, to embark on a development program of a supersonic transport.

That concludes my statement, Mr. Chairman.

The CHAIRMAN. We thank you for a fine statement, Mr. Tipton. Would you give us a little background on the Air Transport Association of America? Who are the members of the association?

Mr. TIPTON. The Air Transport Association is an association of scheduled airlines of the type that I am sure the members of this committee are familiar with; the airlines who serve in this country, American Airlines, Eastern Air Lines, United Air Lines, the airlines who serve abroad, Panagra, Northwest, Braniff, airlines in Alaska, airlines in Hawaii; all scheduled airlines are members of the Air Transport Association.

It is an organization that is almost 25 years old now. Its function is cut across the whole field of air transportation; operations and engineering problems, financial problems, legal problems, a variety of them and, as you can see from this morning's presentation, we attempt to represent our industry before the Congress as well.

The CHAIRMAN. Now, does your statement meet with the views of the association?

Mr. TIPTON. Yes. It follows the views of the members of our association.

The CHAIRMAN. And you recommend cooperative action within the Government. You recommend legislative cooperation with the executive branch by establishment of a committee or commission. You also recommend, do you not, cooperation among the transport carriers?

Mr. TIPTON. We would expect surely to cooperate to the fullest in this developmental effort and unquestionably can help provide for this project, the expert work of airline operations, engineering, and economic people.

As I said in my statement, this is such a broad project involving so many areas of our business that we feel that that kind of cooperation is essential.

The CHAIRMAN. Do you feel that the Government should design and build a prototype?

Mr. TIPTON. We think the Government must take the leadership here and that the Government must assume at the outset the financial responsibility, not because we like to say that, but because we cannot. We do not believe the Government should actually do the physical work of designing the aircraft. I think our Government should rely upon our thoroughly competent aircraft manufacturing industry with the Government's leadership, to actually do the design, development and testing work necessary to produce the airplane.

The CHAIRMAN. You don't believe that private industry has the financial resources to undertake this job even by cooperative methods?

Mr. TIPTON. I would feel sure that they do not have. I am not expert on the aircraft manufacturing industry and its financial re-

sources. I am relying upon statements of men who have said so. I can say to the committee with great confidence that the air transport industry at the present time, even by pooling its resources, could not undertake this because, as the committee knows, we are right now in the process of introducing the big jets and new turboprops into the system. We are replacing almost our entire equipment with very heavy financial burdens as a result of that.

So, while we believe this should start moving now, we are not in a position to say that we could finance it because we are now engineering the present equipment revolution but in our business, as is always, you have to anticipate the next.

The CHAIRMAN. The carriers probably would not be able to use that type of plane now, even if it were available; but the history of World War II showed that planes that we had on the design board before the war were not available until after World War II ended; isn't that true?

Mr. TIPTON. That is exactly right.

The CHAIRMAN. Therefore, you have to plan and work for the future.

Mr. MCDONOUGH. Mr. Chairman.

The CHAIRMAN. Mr. McDonough.

Mr. MCDONOUGH. I have another meeting, and I would appreciate the opportunity to ask a few questions before I have to leave.

The CHAIRMAN. The Chair will recognize Mr. McDonough.

Mr. MCDONOUGH. I appreciate your statement as one coming from an organization representing air transportation, and your desire to advance the state of the art to the point where it will provide better transportation.

As I see it, I think we have made a step in the direction of supersonic transportation with the X–15. It is the only craft that I know of that was planned, designed, and is attempting to reach an elevation of 100 miles with rocket propulsion.

The problem of the Federal Government, laying down the fundamental basis for supersonic transportation to qualify the expenditure necessary in my opinion would have to be based on some military use.

I don't think we ought to merely take it on the basis that this is a good thing for the industry and that we will experiment with it and finally turn it over to industry after we have taken all of the bugs out of it.

We have to have some practical use for it.

Yesterday General Quesada was here and I asked him if he saw some military benefit in this kind of craft and he said he did think there was such benefit.

The suspension of the B–70 is regrettable. I think we should pursue that because I think we were on the right track. We had gotten to the point where configuration was pretty well understood. I think we have the power units. The power units are known. The configuration for large craft to carry 200 people is not known at the present time, but all we have to do is to put these units together and start trying them out. Based on the fact that we have to get to some spots on the earth in a great hurry, which was emphasized a little bit by the experiences we have had in the last week in Paris, I think the Federal Government ought to pursue it. I appreciate the fact that

you came here this morning to encourage this committee in its pursuit of that objective.

Mr. TIPTON. Bearing upon the military usefulness of the supersonic transport, our experience over more than 20 years—the experience that I personally have watched—has provided a good demonstration of that.

Sometimes the transports have been developed by the airlines and the military has found use for them—good use for them.

The military has developed military aircraft and we have found use for the lessons that they learned. A military bomber or other kind of aircraft normally cannot be turned over to industry without a substantial amount of increased work on it, but the lessons that are learned are put to advantage there.

As General Quesada pointed out, the commercial transport cannot be taken directly from the military, but the military's work on it contributes to the perfection of the airplane.

Generally speaking, the reason that a military aircraft cannot be promptly moved into commercial service is the extremely rigid safety requirements that go into commercial aircraft—as they should—that are not applicable to the military counterpart.

Mr. MCDONOUGH. You will recall that yesterday General Quesada said that FAA should not do the experimental work, that it ought to be the responsibility of NASA.

Mr. TIPTON. I had thought that while General Quesada seemed to be a little bashful about saying so, I had thought that he considered that it was appropriate for FAA to take the leadership in the development of the commercial transport, bringing to their aid NASA and the other technical and operating organizations of the Government. That was what I understood his position to be.

Mr. MOELLER. The general seemed to be quite strong in his thinking that should the Government invest large sums of money in the development of such a supersonic jet that there ought to be some sort of royalty paid back to the Government so that a portion of this money at least comes back from the manufacturers or the users. Would you agree with that?

Mr. TIPTON. I emphasized to the chairman that my statement reflected an industry position. I can't make a flat statement on that point because I haven't asked them on that point. Mr. Six, who is president of Continental Airlines and a member of my board of directors, has addressed himself to the subcommittee in support of such an idea.

In the past, the industry has always made its contributions to the developmental cost of the airplanes in the purchase price.

Now, I think that one of the problems that the Government should work out in this process is how the contribution to the industry should be made to this project. Whether in the purchase price of the aircraft, whether it be a royalty, or as the chairman discussed yesterday, some kind of a tax.

In principle, I would not have much hesitancy in saying that our industry would agree to the principle of contributing a fair share to the development cost of the airplane.

The CHAIRMAN. Will the gentleman yield?

I made that reference because, in the case of the Viscount, which is a British plane—and we have a representative of the British Parlia-

ment here with us today—in the case of the Viscount the British provided for a royalty, which is just another way of saying tax, on it. When the planes were sold to the carriers part of the purchase price helped pay for the cost of the development of the Viscount. That was the reason I mentioned it.

Mr. TIPTON. It is a little hard at this stage to know the practical effect of that principle because a high percentage of the development cost is going to be for military purposes; that is, in our general national interest. Another portion will go to private interests and some formula will have to be developed in the course of this so that those who benefit privately from these expenditures make a contribution to it. I think that is true.

Mr. MOELLER. I fail to understand how you could say that this development would be directly beneficial to the military. As I understand it, we are to copy from the B–70. We are to get the information and we are to get some benefits from the advanced research that the military has already carried forward.

Mr. TIPTON. But the benefits of that also go back to the military, because what will be built here will be a transport that the military can use also. These lessons always feed back and forth. The military develops a bomber. The manufacturers then take lessons they learned from the bomber and build a transport. We buy the transport. We use it. We learn lessons about the use of it and that feeds back to the military. Our commercial and military efforts in the aviation field have always been done in that fashion, which, of course, is what should be done.

The CHAIRMAN. Mr. Fulton?

Mr. FULTON. General Quesada stated that the development of the configuration of this proposed 2,000-mile-an-hour transport plane should be made to operate within the limits of the present runways of our air terminals. I doubt whether that would be possible. Would you comment on that? Should we plan on such a thing?

If we are going to have these tremendous planes carrying 200 people at the speed of 2,000 miles an hour, with tremendous weight, it would seem obvious that you would have to plan heavier runway construction, as well as longer runways.

Mr. TIPTON. My comment on that would be as follows: I think that in the design and development of this airplane, one of the objectives should be that we seek to provide for the utilization of it on existing airports to the greatest extent possible. But in the design and development of an airplane, a mandatory limit that you must do that might well cripple the economics of the airplane itself.

Mr. FULTON. Should there be an arbitrary limit set on the development of this 2,000-mile-an-hour transport, the configuration must conform to present-day practices on airports?

Mr. TIPTON. I am quite clear that no arbitrary limit of that kind shall be set. I think that should be an objective. It is surely one that the airlines would want to achieve. Because if we have an airplane the use of which requires great extensions of airport runways and strengthening of them, then that, of course, enters into the economics of the airplane itself because the airports do not provide those facilities for us free. If it requires those improvements, then either immediately or over a period of years we have to pay for them. Surely

that is an objective we would want but we would not want an arbitrary conclusion, surely not at this stage of the game, when we really know so little about it.

Mr. FULTON. There is the problem of noise near populated areas and the obstacle pattern that is even unsatisfactory for ordinary planes. If you bring in a 2,000-mile-an-hour plane you have a different landing pattern or takeoff pattern than you do on the regular commercial type we have now. Is that not the case?

Mr. TIPTON. While this is a revolutionary airplane, the actual handling of it might be fitted into our existing traffic patterns without too much difficulty. That is something we don't know, yet.

May I introduce Mr. William Becker, director of operations and engineering of the Air Transport Association, to comment on that.

The CHAIRMAN. Do you have a comment in reference to that?

Mr. BECKER. I would say it is highly probable that it would work in the existing system. I am talking about the air traffic control system. Certain things would have to be done, as General Quesada said yesterday to the air traffic control system, to be able to speed up communications between the air traffic control personnel working on the ground, so that they are ahead of the airplane, so to speak. Today, we have to stay ahead of an airplane that is traveling across the country in 4 to 6 hours and if it is going to be traveling across the country at a speed of 2 hours for transcontinental, our communications are going to have to be stepped up.

But as to mixing in with other aircraft, I don't think this would be any more difficult than it has been to mix our jet aircraft in with the DC–3's and F–27's now operating into and out of our major airports.

Mr. KING. Mr. Tipton, I don't understand what your recommendation is with regard to the division of responsibility between the Government and the private aviation companies with regard to the research and development work on this program. Is it a matter of the Government paying a subsidy to one or more private companies who will work in concert to work out these programs, with the Government just subsidizing and no more; or on the other hand will the Government actually be a partner in this work, to some extent?

Mr. TIPTON. I think the way this has to be done, based upon the present financial condition of both aircraft operators and aircraft manufacturers, is that the Congress, either by substantive legislation or by appropriations should determine that the supersonic transport is to be built and it is our recommendation that they designate the FAA to get it done, using the facilities of the Government and of private industry to get it done, and make the necessary appropriations under which they could, for example, enter into a contract with a manufacturer, or manufacturers, to develop this airplane and the Government appropriations would pay completely at the outset for the delivery of this prototype and its testing.

The Government in the process of doing that would call upon other agencies of the Government and industry for advice and consultation and the like, but would do it through Government appropriations. Then under a contract with a manufacturer or several of them, if that is the way it developed. And when the airplane was developed and tested and given its appropriate certification by the Government for commercial use, the airlines would buy it—would finance the pur-

chase of it themselves. And in the course of that purchase we encounter the question of, to what extent should they contribute back this developmental cost, as they purchase the airplanes.

I don't know how to do that right now.

Did I answer the question?

Mr. KING. Yes. You are saying that one or more aircraft companies will work under contract for the Federal Government to produce a prototype which becomes the property of the Federal Government and they in turn buy it back on a "consideration to be agreed upon" so that the Federal Government would be reimbursed for all or part of its investment. I understand that. There is still one facet of this upon which I am not clear. When Dr. Wernher von Braun was before our committee he testified that in his opinion it would be well if for every $10 the Government gave to private industry, it ought to spend $1 inhouse for research and development work in that general field. His idea was, as I understand it, that if the Federal Government gets too far removed from this technical work in which it has such a great interest, then it doesn't know enough about it to be able to understand properly whether a good proposition is being made by one or more private industries. So that in order to, shall we say, keep their finger in the pie, so they will know what is going on and be able intelligently to appraise the value of what is being offered, they ought to spend at least 10 percent themselves in their own R. & D. work.

Now, would you agree with that?

For example: Should NASA be prepared to spend perhaps 10 percent of the figure that you suggested, which might range anywhere from $200 million to over a billion dollars?

Mr. TIPTON. I have a tendency to answer where I don't really know enough about the subject. This is one such subject. I really don't know enough about research and development to know whether that is a sound idea or not.

One thing seems clear to me, though, that this aggregate of Government agencies that necessarily will work on this should have within their own capacity a sufficient staff to be able to provide the leadership that I recommended. I think that is essential. Whether that is 10 percent or 2 percent of a particular project I wouldn't have any idea. But it clearly needs a staff to provide the supervision and the, as I have called it, leadership required here.

Now, we have in the Government, as we pull them together in this field, we have the Defense Department, the Air Force with great technical capacity on their own staff. We have NASA with the technical capacity on their staff. We have the FAA and within a somewhat more limited field the Civil Aeronautics Board.

So the Government, through the consolidation, so to speak, of its resources would have a considerable capacity.

When you add to that—as it should be added—the technical capacity of the airlines and the manufacturers I would think we would aggregate the brains to do this job effectively.

The CHAIRMAN. Will the gentleman yield?

Mr. KING. Yes.

The CHAIRMAN. Are you familiar with the arrangements which were set up to build the U.S.S. *Constitution?*

Mr. TIPTON. No.

The CHAIRMAN. The U.S. Government contributed to the building of it, and certain designs were changed to some extent so as to make it suitable in time of war as a troop carrier. That was our justification for entering into and helping to build it. Now, I am just wondering if we shouldn't pursue that to see just how that worked.

Mr. TIPTON. I am sorry, I am just not familiar with that.

In the air transport industry we have never had any direct contributions by the Government to develop our commercial transports. And I should say, this is not something that we like to come to Congess and recommend, that the Government do make a contribution. But we believe, in the interests of national prestige and national defense, this transport is necessary. For that reason we can come up and make a recommendation that the Government should help, as it never has before.

We make that recommendation not in the selfish interests of the airlines, because we really have all we can do right now to deal with the rapid advancement of jet transportation. We are making a recommendation here that we believe is necessary in the national interest so that the United States will not fall off its present pinnacle as far as aircraft leadership is concerned.

Mr. HECHLER. Mr. Tipton, I think your statement shows a lot of imagination and conviction and I commend you for it.

Of the questions the committee has asked, the question of financing is particularly close to our thinking here. I am particularly glad Mr. Moeller brought out some of the points he did.

I don't want to sound too much like a McKinley Republican when I ask these questions, but it always disturbs me when the Government is put into the position of getting into a big area like this.

Now, we know for a fact that a supersonic transport will be developed. You stated that in your prepared statement. The question is how it can best be developed.

Would you consider that it is absolutely impossible for private enterprise to, through floating stock perhaps, to raise sufficient financing for such development?

Mr. TIPTON. First, with regard to McKinley Republicanism, I have sometimes been referred to as one myself. I thoroughly understand your question and have great sympathy for it.

The practical fact at the moment is that with the current obligations of the airlines system, I am quite sure that we could not raise by equity sufficient funds to go into this project. As a matter of fact, we started about 3 years ago with an investment of $1 billion in the entire air transport industry, and the jet revolution has caused us and will cause us over the next 2 years to add to that about $4 billion. And we are having trouble now in keeping our equity up to the point where it should be.

Now, with regard to the manufacturers I can only quote here from conversations, and it appears that their situation is about the same as ours.

Mr. HECHLER. Well, now, this is a sure thing for a private investor. It is definitely going to be developed. All you have to do is go out and round up the venture capital. You are suggesting that this just does not exist in this country outside of your own industry.

Mr. TIPTON. It is a sure thing that the supersonic transport will be developed, but the difficulties to be encountered between the time—between this morning and the time one is certificated and flies, are to some extent known, but also to a large extent unknown. That would be really a venture.

Mr. HECHLER. Let me ask you this: Is this a difficulty in lack of technical personnel outside of the Government? Outside of Government representatives, researchers and technologists, you would be able to moblize the technical know-how, would you not?

Mr. TIPTON. Oh, yes, indeed. I answered that too quickly. I want to emphasize the necessity of aggregating our technical personnel, our country's technical personnel but if we did that we have the know-how to do it.

Mr. HECHLER. Then the question is primarily one of financing, is it not?

Mr. TIPTON. Yes, it is a question of——

Mr. HECHLER. There is no necessity for the Government R. & D. people to do this by reason of any lack of technical know-how in private industry. That is the point I wanted to make.

Mr. TIPTON. Yes, I would say that is right.

Mr. HECHLER. Would you look with any favor on a possible Government tax break for those who would contribute toward the financing of such an operation? I would like to explore any possibility that this could be done privately rather than putting the burden on the Government. Again I don't want to sound too much like a McKinley Republican but I want to explore the possibilities for it.

Mr. TIPTON. I have never given any thought to that possibility. It would have to be quite a tax break, I think. Possibly more tax break than you could ever get, simply because the risks in development are high. We have a lot of estimates about the economic potentiality of this airplane but it is not something that you can sit down and prove. We think it is going to be a very productive airplane when it is built but it might well not be.

I would be doubtful of the possibility of a tax break being an adequate incentive to creating an equity pool of, say $500 million to do this.

Mr. HECHLER. One final question which may be a little off the subject. It seems to me your entire emphasis here has been placed on developing a fast means of transportation between cities. Isn't our major problem how to get them out of the airport back home?

Mr. TIPTON. How to get them from the airport home?

Mr. HECHLER. Yes.

Mr. TIPTON. It is a major problem.

Mr. HECHLER. It is the biggest problem, is it not?

Mr. TIPTON. Well, I suppose it sometimes seems a considerably harder problem.

Mr. HECHLER. When you add it up, it actually adds up to more time; particularly when you get these supersonic transports into operation. You will be spending maybe 3 hours back and forth to the airport and 30 minutes in the air.

Mr. TIPTON. We have to try, as we are trying, to perfect our ground transportation to the extent that it will match the speed in which you move. One way in moving in that direction, of course,

is helicopters and that I think is beginning to look brighter from the standpoint of the economics of the machine and the method of operating it. But you have put your finger on a very difficult problem as far as air transport is concerned and you have said exactly what is true, that we speed up the airplanes real fast and then we put people down on the ground and they have trouble getting into town. That is something we have been working with now for 20 years.

The CHAIRMAN. I want to ask you two or three more questions. Do you think that this country should develop a mach 2 plane before it develops a mach 3 plane or would you prefer to see our efforts go into the development of mach 3 planes?

Mr. TIPTON. Based upon the best engineering advice I can get and read, it appears that our engineers and economists who study the plans for these airplanes find no reason to develop a mach 2 airplane, that they might as well go to mach 3 rather than going through the steps.

The CHAIRMAN. There is no use to compromise it; go the whole way?

Mr. TIPTON. That is right.

The CHAIRMAN. If the Russians produce an operational supersonic aircraft before we do, what would be the impact, in your judgment, on our national prestige?

Mr. TIPTON. It would be a very, very serious—it would have a very serious adverse impact. Unquestionably, and the Russians, of course, would do their best to see to it that it was as serious and as adverse as possible.

The CHAIRMAN. I don't think there is any doubt about that.

Mr. TIPTON. And I wouldn't have much doubt that some day, and possibly before not too many days we will have a Russian air transport service between our country and Russia. It may have had a little setback here recently. But then our carriers have that direct competitive impact of one operator moving his goods and passengers at 2,000 miles an hour and the other at 600. The operators would be placed in a very difficult position at that point.

The CHAIRMAN. That leads to the question that I was going to ask you: The impact on our domestic aircraft manufacturing industry would be very serious, wouldn't it?

Mr. TIPTON. It would be very severe because if the Russians or other foreign countries were to develop a good supersonic transport, the world's airlines have to buy it.

The CHAIRMAN. We would have to go to some other country to make the purchase, and I doubt that our terms would be very lenient if we had to deal with Mr. Khrushchev.

Mr. TIPTON. I would doubt it, too.

The CHAIRMAN. Mr. John Adams of the CAB testified yesterday that the competitive impact of the supersonic transport will be such as to force long-haul carriers to acquire them, whether or not they have amortized their investment in subsonic jets. What is your comment?

Mr. TIPTON. I would concur fully. Our experience for many years has been that it is very, very difficult to hold the traveling public on an airplane that is slower in speed than another one that is available. So the carriers must acquire the fastest equipment. That is one reason

our industry has followed the practice for many years of writing off their equipment very quickly—comparatively quickly. We are writing off the jets generally over 10 years. I do hope that that is a long enough period.

The CHAIRMAN. Yesterday, the House passed a bill to encourage private industry to build plants in other countries of the world.

Now, the impact of such a supersonic transport program would seem to be very definite, is that right?

Mr. TIPTON. Yes.

The CHAIRMAN. And furthermore, our program of global defense maintaining contacts with Britain, with Australia, with India and with other allied countries throughout the world would be terrific, it seems to me, by having a fast plane such as this.

Mr. TIPTON. There is no doubt that it would revolutionize transportation. It has been going on for years. We have pulled closer and closer together and it would happen again.

The CHAIRMAN. Do you have any questions, Mr. Hammill?

Mr. HAMMILL. I have no questions, Mr. Chairman.

The CHAIRMAN. I think we have pretty well covered the questions of the members of the committee.

We have a colleague here, Mr. Riehlman, who normally is very talkative but today he is silent. He has laryngitis. We have tried to ask the questions we feel Mr. Riehlman would want to ask you.

We are also honored in having Mr. Finch, a member of the British Parliament, here today. We are pleased that he has chosen to take time to sit in with this committee. I am sure he notes the reference we have made to British accomplishments in aviation and I am happy that this country is able to walk hand in hand with our cousins across the seas from the British Isles, in the development of aircraft and also in the defense of the free world.

We are happy to have you, Mr. Finch.

Mr. FINCH. Thank you very much. It has been a pleasure.

Mr. TIPTON. I might add, Mr. Chairman, we find the British operators to be very, very strong and fair competitors, and I am honored to have an opportunity to testify when you are here.

The CHAIRMAN. Mr. Finch is here through the courtesy of Mr. Fulton.

Mr. FULTON. May I welcome him from the Republican side.

Mr. Moeller had been talking with me earlier and the question came up of the possible cooperation of the British with the French, and West Germany in the construction, or the research and development of such a fast plane.

Why are we all competing with each other? Why don't we pool resources and really get ahead faster if we in the western world are in competition with the Soviet? Why don't we do it? Couldn't we?

Mr. TIPTON. There has been discussion of that. It may be that I am demonstrating a frozen mind here, but I would not think that would work very well. Our methods are somewhat different. Our engineering ideas differ somewhat. I think we both come out with a good product but we do it differently. I think it would tremendously increase the difficulty of the project if we sought to make it a combined multicountry project.

Mr. FULTON. If France can do it in cooperation with West Germany, why couldn't the United States do it in cooperation with the British, or with any one of the others, or both?

The CHAIRMAN. Or all of them.

Mr. TIPTON. I think it would be very difficult. I also think that the possibility should be explored. I think it should be explored.

The CHAIRMAN. Thank you very much, Mr. Tipton. We appreciate your valuable testimony.

The subcommittee will now stand adjourned until tomorrow morning at 10 o'clock.

(Whereupon, at 12 noon, the subcommittee adjourned to reconvene at 10 a.m., Friday, May 20, 1960.)

SUPERSONIC AIR TRANSPORTS

FRIDAY, MAY 20, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SPECIAL INVESTIGATING SUBCOMMITTEE,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The subcommittee will come to order.

This morning we are going to hear from representatives of the aircraft manufacturing industry. We have Mr. Atwood, the president of North American Aviation; and Mr. R. C. Sebold, vice president, Convair Division of General Dynamics.

Before we begin hearings, I would like to say that we are happy to have Mrs. Harkins' civics class from Kensington Junior High School, Kensington, Md., here. I am sorry our accommodations are so limited that we don't have enough seats for everyone. However, we are glad to have these young people here. I know of their interest in the work of this committee.

Mr. Bass, I would like to recognize you at this time.

Mr. BASS. Mr. Chairman, I would like to recognize the presence of Mr. Lloyd Goodmanson, who is manager of supersonic transport development of Boeing Aircraft Corp. He is here in this room. In view of the short period during which these hearings are being conducted, I recognize that it is not possible to hear everyone who would like to testify in connection with this important matter but I did want to bring to your attention, Mr Chairman, and to the committee's attention, Boeing's interest in this field and to note that Mr. Goodmanson is here.

The CHAIRMAN. Mr. Bass, we have had to cut down the number of days to be consumed by this hearing. We would like to have had many more witnesses. Counsel to the committee, Mr. Hammill, who has done an excellent job of organizing these hearings, wanted at least 3 additional days in which to hear other interested parties, but I believe the committee could not afford the time.

Now, for that reason and because of your interest in recognizing Boeing, we would be very happy to have Mr. Goodmanson file a statement for the record. The committee will be pleased to consider his statment in reference to the problems before us.

Mr. BASS. Thank you very much, Mr. Chairman. I believe Mr. Goodmanson would like to have that privilege.

The CHAIRMAN. If there is no objection the record will be open for the statement of Mr. Goodmanson.

(The statement referred to follows:)

BOEING AIRPLANE CO.,
TRANSPORT DIVISION,
Renton, Wash.

Mr. CHARLES F. DUCANDER,
Executive Director and Chief Counsel,
Committee on Science and Astronautics,
House of Representatives.

DEAR MR. DUCANDER: We welcome the opportunity extended by your letter of May 4 to present our views and suggestions concerning development of supersonic transport aircraft. The subject is, of course, of vital interest to us as production of jet transports is a major portion of our total business. Currently, over one-half of the pure jet transports in service on the free world airlines are Boeing built. We intend to retain a leading position in the business of designing and producing transport type aircraft for both commercial and military use.

As part of our effort to carry out this intent, we have had since 1957 a sizable group of our top engineering talent engaged in research, testing and preliminary design activities specifically directed at development of a supersonic transport. All of this activity, including an Air Force requested study of supersonic transports has been Boeing financed. Over $4 million have been spent to date on studies aimed at development of the supersonic transport.

As a result of our work, we are certain that a satisfactory supersonic transport could be designed in the near future. We believe that the technical competence necessary to design and build supersonic transports is not confined to the United States. British and French plans have been well publicized recently, and persistent rumors indicate that the Russians are also well underway. If we hope to retain our present dominant role in world air transportation, we must initiate an intensive program for development of supersonic transports in this country in the very near future.

We strongly recommend a two-phase program:

1. A period of greatly intensified research both by the NASA and by private industry.

2. Design, construction and flight evaluation of two or more prototypes. This program should be timed so that first flight of supersonic transport prototypes would occur in 1963 or 1964 at the latest.

RESEARCH

The first phase is extremely important because the quality of the supersonic transport—its ability to compete economically with subsonic transports, its reliability, and its safety—will depend in large measure on the research and development put into it. The risk of technical obsolescence in a field as new as the supersonic transport is severe and the only real protection against early obsolescence is research.

Research applicable to airplanes has diminished very severely in the past few years. Financial support of both military and the NASA research has shifted strongly away from airplanes toward missiles and space. We urge that NASA research applicable to supersonic transport problems be greatly accelerated.

In this connection, the Boeing Airplane Co. recently submitted to NASA a list of research items involving flight, wind tunnel, and structures tests which we feel should be initiated or expanded. Some direct or indirect financial support of supersonic transport research programs in private industry should also be considered if we seriously intend to compete timewise with our foreign competition.

DEVELOPMENT OF PROTOTYPES

The manner of handling the hardware development program which follows the research phase will have considerable bearing on the quality of the final product. No American manufacturer appears to be in a financial position to undertake a supersonic transport prototype without outside help; therefore, some form of governmental support of prototype activity is undoubtedly necessary.

We believe that success of the supersonic transport will be far greater if the actual hardware is developed in a competitive environment. The 707, DC-8 and 880 airplanes are each much better because of the existence of the other two. We feel that serious consideration should be given to a program which will provide two or more competing prototypes. In the long run, the governmental expenditures necessary to insure a top product may be considerably less

using this procedure than by funding a single manufacturer following his selection prior to hardware development.

Additional comments on supersonic transport development will be found in the enclosure.

OPERATION OF SUPERSONIC TRANSPORTS

The principal use for the supersonic transport will be on the long range routes, particularly transocean. On the shorter runs, the speed advantage over the present subsonic jets will be small due to the portion of the trip time spent in airport traffic and in accelerating to and decelerating from supersonic cruise. The supersonic transport will be much less economical than the subsonic jets on the shorter runs. For these two reasons, the supersonic transport should be considered as a supplement to the subsonic jets, which will continue to dominate the medium and shorter range routes.

Operation of the supersonic transport over heavily populated areas will be somewhat questionable until high altitude flight tests of heavy airplanes are run at supersonic speeds. However, a very high percentage of long range air routes is over oceans and land areas of low population density; therefore, the potential need for supersonic transports is large regardless. By 1975, there may be as many as 400 supersonic transports flying the airlines of the free world. This prediction requires that supersonic transport fares be as low as those of subsonic jets and that reliability and safety are equivalent.

Early implementation of the above program will assure that the United States supplies a large share of the potential requirement. We must act now if we are to be the leader in world aviation in the time of the supersonic transport.

Very truly yours,

J. O. YEASTING,
Vice President-General Manager.

NOTES ON SUPERSONIC TRANSPORT DEVELOPMENT

THE INEVITABLE SUPERSONIC TRANSPORT

The underlying reason behind all significant increases in travel popularity undoubtedly is speed. Certainly the early transport airplanes did not compete in comfort or convenience with Pullman cars or luxury ocean liners, yet air transport not only survived, but prospered. The traveling public, in large part, seems to believe that time spent simply in traveling from one place to another is time ill spent—they would rather invest their time at those places.

For this reason, we must conclude that whenever a faster means of transportation is available, it will be welcomed by the public, with the only deterrent to increased popularity being cost. It must be inevitable, then, that the supersonic transport airplane will be the next step in man's progress in the art of transportation. The only questions are how soon, and how fast. In the following pages, we will examine some of the major problems involved in trying to answer these significant questions.

SPEED CHOICE

Two significant points when establishing the cruise speed of the supersonic transport are approximately mach 2 and mach 3. At about mach 2, the kinetic heating of the airframe has increased to the maximum temperature at which aluminum alloys, the traditional and most highly developed airframe materials, can maintain usable strength and higher speeds will require use of steel. At mach 3, the kinetic heating of the airframe has increased to such a degree that although stainless steel structure still has appreciably higher temperature capabilities, the airplane systems have reached a virtual temperature limit. For this reason, an enormous amount of industrywide development work will be required to provide powerplants and airplane systems of sufficient reliability for a passenger carrying vehicle when considering a step beyond the mach 2 level.

An examination of the block time (total elapsed time) versus mach number plot below (fig. 1) shows that for a transatlantic range, relatively large block time savings can be achieved for increases in cruise mach number up to a speed of about mach 2 to 2.5. Above this speed range, the block time saving diminishes until only relatively insignificant savings can be made above mach 3.

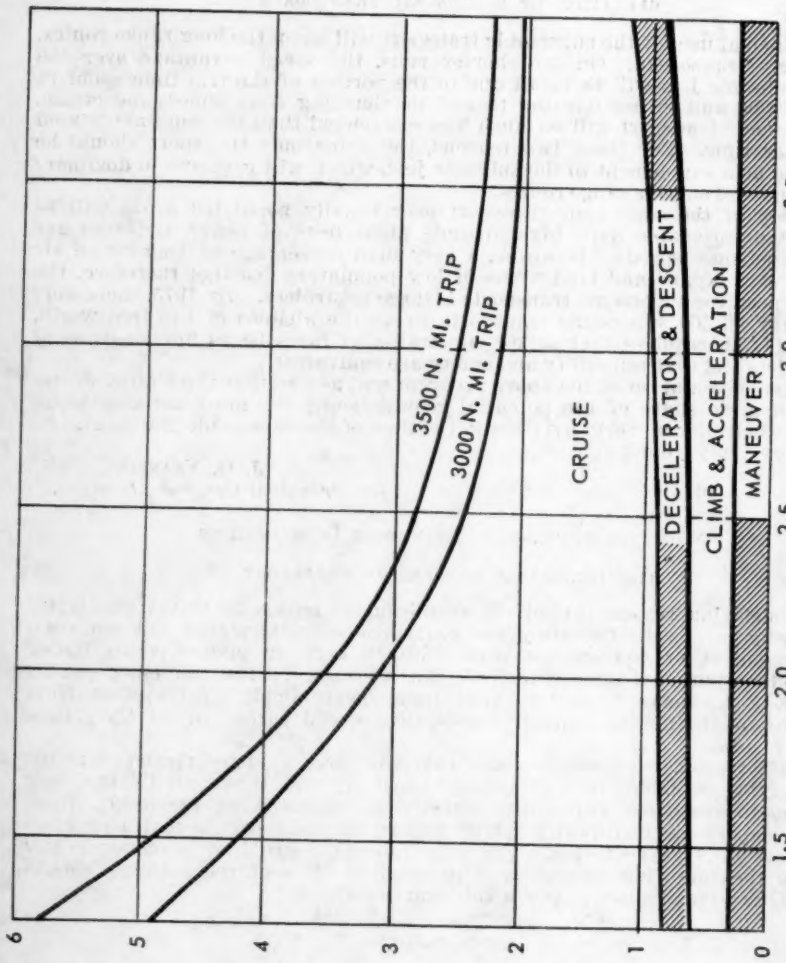
BLOCK TIME (HOURS)
6
5
4
3
2
1
0
3500 N. MI. TRIP
3000 N. MI. TRIP
CRUISE
DECELERATION & DESCENT
CLIMB & ACCELERATION
MANEUVER
1.5
2.0
2.5
3.0
3.5
4.0
CRUISE MACH NO.

FIGURE 1

From a technological/operational standpoint, the speed of the initial supersonic transport thus probably ought to be in the mach 2 range. However, competition for the supersonic transport market will be keen and could easily force the more drastic step to the higher speed range. Growth capability will be important and since an aluminum airframe will have no appreciable speed growth, the initial supersonic transport may be made of stainless steel even if operated originally near mach 2 speeds because of system temperature limitations.

RANGE, SIZE AND ECONOMIC CONSIDERATIONS

The supersonic transport should have nonstop capabilities over most blue ribbon routes since speed is its great asset. The distances shown below (fig. 2) are representative of globewide range requirements. These range requirements, together with economic considerations, will result in a transport grossing over 400,000 pounds.

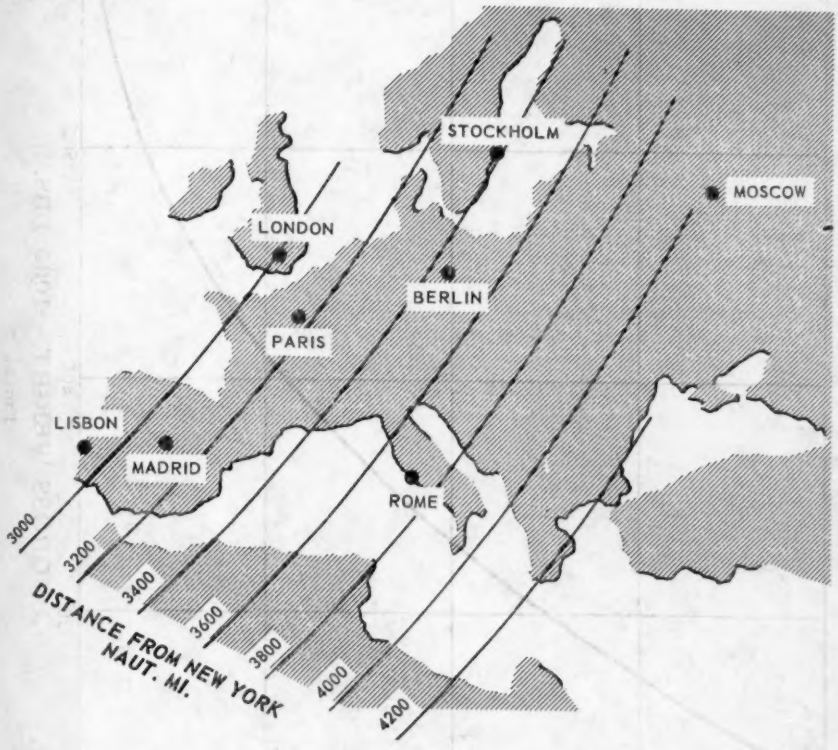

FIGURE 2

In the past, introduction of new and faster airplanes has made good sense because operating costs generally came down as speeds went up. Certainly in the case of the jet transport, the increase in speed was accompanied by a very significant reduction in seat-mile costs. These cost reductions were possible partly because the airplane size (gross weight) and the payload (number of passengers) were increased at the same time. For example, the 707 is more than twice the size of the DC–6, carries almost three times the payload, and the seat-mile costs are approximately 15 percent less.

The supersonic transport is faced with the same situation. In order for seat-mile costs at higher speed to equal or better those of the subsonic jet, the size and payload must be increased. The effect of airplane size (gross weight) on seat-mile costs for mach 2 transports is shown on the curve below (fig. 3). Seat-mile costs for supersonic transports with a nonstop North Atlantic range capability are given relative to those of the 707–320.

SEAT MILE COST RATIO
MACH 2 TRANSPORT
707-320

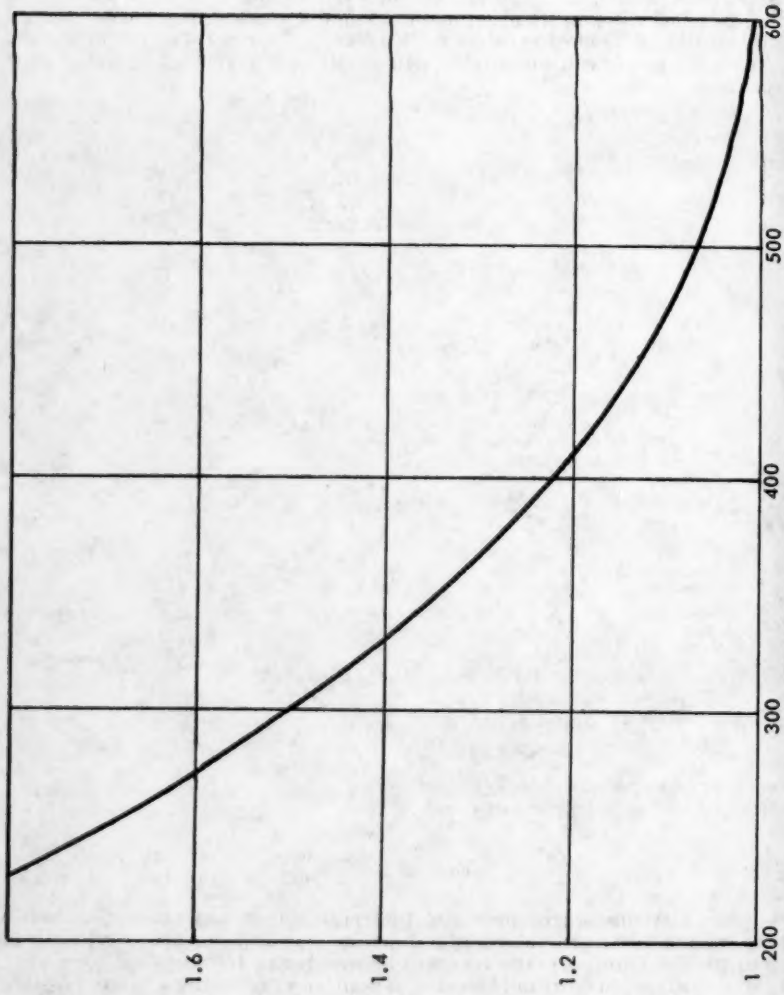

FIGURE 3

From the operator's standpoint, the size of the airplane will be greatly influenced by its adaptability to his route net. A large airplane with good range, many seats (and thereby a low seat-mile cost) will not be very feasible on anything but high density routes. A smaller airplane, although not optimum for the longest routes, would be usable on a number of medium-haul runs and probably give most operators a better economical overall result. It can be seen from the above diagram that seat-mile cost increases fairly slowly initially as we start decreasing weight from 600,000 pounds.

MARKET

For economy reasons, the supersonic transport will primarily handle long-range traffic. Consequently, the subsonic jet will probably continue to dominate the medium-range market for years to come and will likely capture a large percentage of the short-range market as well.

Another factor limiting the supersonic transport market is undoubtedly the sonic boom. A recent Boeing investigation, corroborated by NASA wind tunnel tests, indicates that large supersonic airplanes will be accompanied by sufficiently intense ground level sonic booms along their flight path to possibly restrict their operations over populated areas. The following plot of pressure differential (fig. 4) shows that this may largely restrict supersonic transports to overwater routes which fortunately form the bulk of the long-range transport operation.

In terms of airplane quantities, the potential market for supersonic transports will be small because of the high work capacity of each airplane. The chart (fig. 5) assumes a traffic growth based on past experience. With supersonic transport certification in 1967, a total production of 50 transports per year beginning in 1968 would appear to satisfy the free world market. By 1975, these supersonic transports would accommodate nearly all the non-noise-critical long-range routes.

In addition to the commercial airline market, there will also exist a military market for the supersonic transport. Judging by the experience with the VC–137, MATS should have a requirement for a supersonic transport simultaneously with the commercial operators.

AIRPLANE COST

Past experience has confirmed the value of a prototype in the development of new aircraft. The practice has been common in the military because each new type has tended to be of considerably advanced design. Commercial aircraft, however, have been somewhat more conservative in character.

In the case of the supersonic transport, the projected performance is expected to be higher than any existing military airplane of comparable size. The B–58 is a high-speed dash airplane only. Although the B–70 is designed as a high-speed cruise airplane, its fate is at present somewhat in doubt. The supersonic transport manufacturer will, therefore, undoubtedly consider a prototype to be imperative, in view of the extremely advanced character of the airplane.

Consideration of supersonic transport program costs, therefore, must include the cost of a prototype. Boeing estimates of the cost of an aluminum prototype are in the order of $50 million. This airplane would be used principally for aerodynamics, powerplant, and primary systems development. It would incorporate little in passenger accommodations or secondary equipment. A steel prototype, suitable for mach 3 development, would cost possibly twice as much.

A production airplane program would result in a similar price differential. The production unit price for a mach 2 aluminum airplane, due to the small market and extensive development costs, would probably be about three times the cost of a similar-sized subsonic jet transport. However, since the work capacity would be about three times as great, the depreciation per passenger mile would be comparable.

The cost of a mach 3 steel airplane, however, is expected to be nearly twice that of the mach 2 aluminum transport, based on present steel design and fabrication technology and radical systems development required. Its block speed would be only about 25 percent higher; therefore, the depreciation cost per passenger mile would be higher.

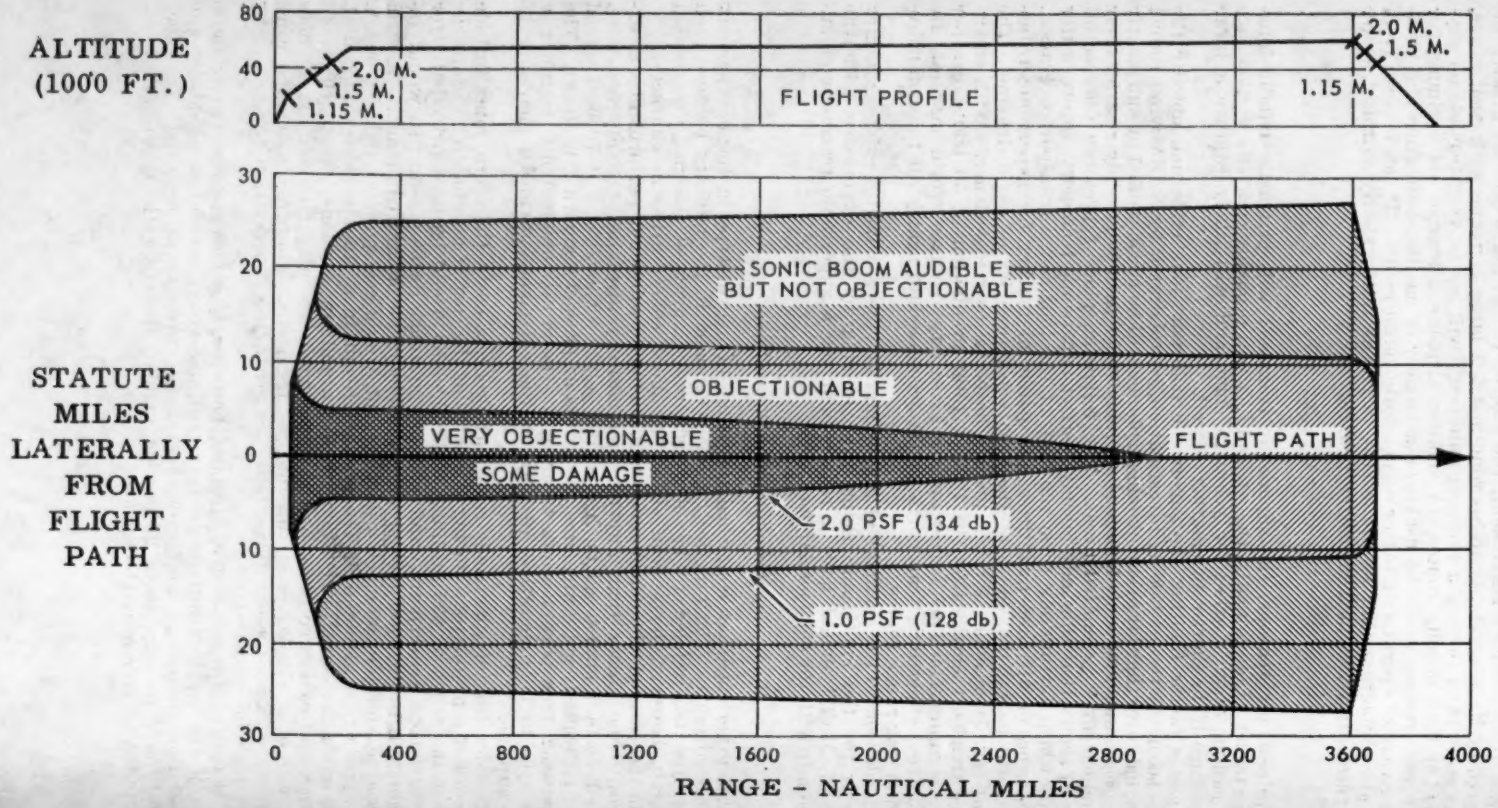
ALTITUDE (1000 FT.)
80
40
0
2.0 M.
1.5 M.
1.15 M.
FLIGHT PROFILE
2.0 M.
1.5 M.
1.15 M.
STATUTE MILES LATERALLY FROM FLIGHT PATH
30
20
10
0
10
20
30
SONIC BOOM AUDIBLE BUT NOT OBJECTIONABLE
OBJECTIONABLE
VERY OBJECTIONABLE
SOME DAMAGE
FLIGHT PATH
2.0 PSF (134 db)
1.0 PSF (128 db)
0
400
800
1200
1600
2000
2400
2800
3200
3600
4000
RANGE - NAUTICAL MILES

FIGURE 4

700

FIGURE 4

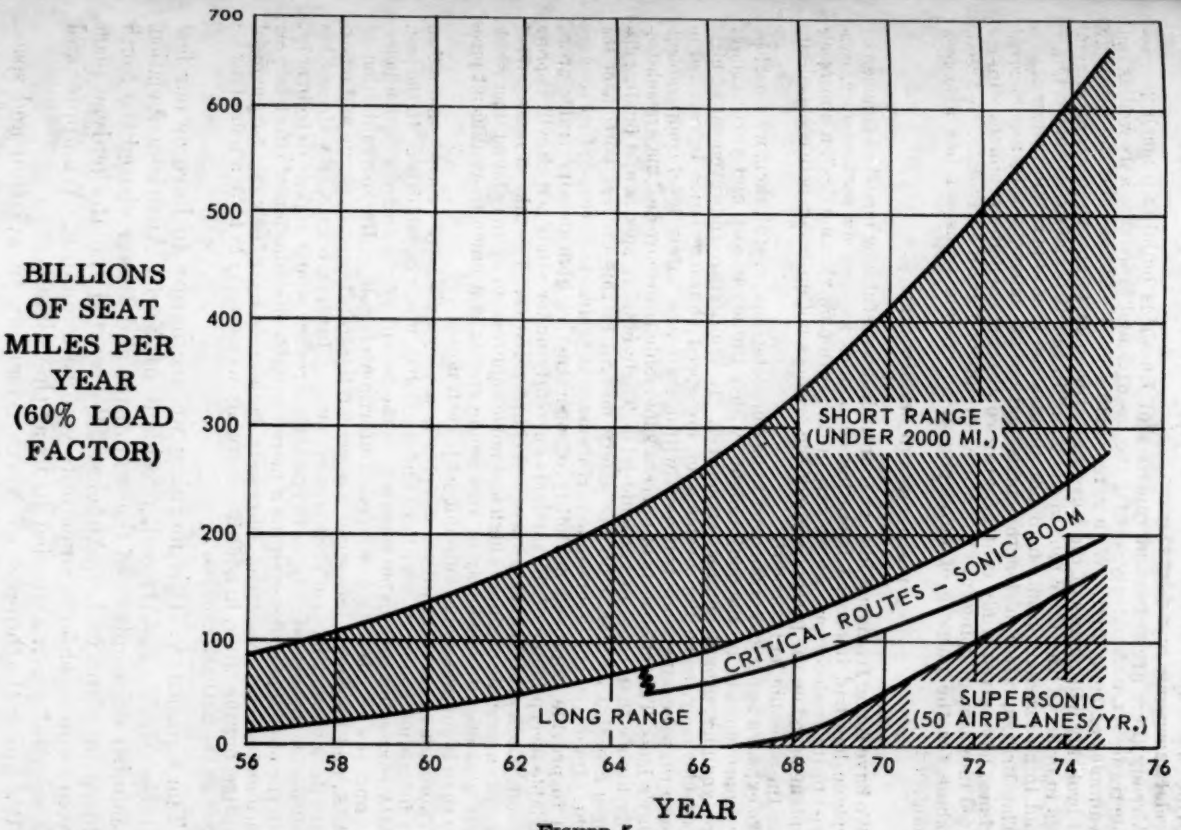

FIGURE 5

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FOREIGN COMPETITION

Bolstered by at least reasonable success in designing and marketing or operating subsonic jet transports, both Britain and Russia will most certainly provide the United States with substantial foreign competition for the commercial supersonic transport market.

Already there are persistent rumors that Russia is building a mach 2 supersonic transport, undoubtedly seeking the prestige and propaganda as well as real advantages of being first. With a reasonably good airplane and the capability and probably willingness of the Russian Government to absorb losses on aircraft sales in order to "get their foot in the door" in the airplane export market, they stand in an excellent position to sell airlines the first supersonic transport.

The British, after a lengthy investigation of supersonic transport speed regimes, have given study contracts to two aircraft company combines with the stated intention of going into hardware development at an early date. A French combine for the purpose of developing a supersonic transport has also been announced.

RESEARCH AND DEVELOPMENT

We have found from past history that each successful new model of commercial airplane has had improved operating economics as well as performance, compared to its predecessor. As we saw in the section on "Economics", a supersonic airplane based on the present state of the art does not quite compete economically with the subsonic jet transport.

To expect a supersonic transport to be completely successful, then, we must look for improvements in the major fields which influence cost and performance: aerodynamics, propulsion, and structures. In addition to improvement of high-speed efficiency, some improvement of low-speed characteristics is required to assure that the supersonic transport will operate at a safety level comparable to today's jets. Takeoff speeds of current supersonic transport designs are substantially higher than those of subsonic jets. Their landing speeds and landing distances are also greater, reducing safety margin in this critical portion of the flight. Improvement in subsonic performance is desirable to reduce fuel reserves and to provide improved flexibility of operation in high density traffic areas. Variable sweep is one of the methods currently under study which will improve takeoff, landing, and general low-speed characteristics. The takeoff noise level of present supersonic engines is high and noise suppression of an exhaust duct which must also operate efficiently at supersonic speeds is a much more difficult problem than is suppression of subsonic jet takeoff noise.

Thorough research in all these fields is a very expensive process—more than any individual company can afford under existing profit capabilities. In the past, NACA carried on invaluable research, to the benefit of the entire aviation industry and the country as a whole. Unfortunately, since its reorganization as NASA, and its plunge into space age research, aircraft aerodynamic and powerplant development has suffered tremendously. Inasmuch as NASA already has facilties for the necessary types of research, a review would appear to be in order, with the objective of determining a more equitable distribution of effort between space and aircraft research. Obviously, both fields have their effect on national prestige, but the latter, in addition, certainly would seem to have a more tangible effect on the national economy.

The CHAIRMAN. This morning we are happy to have as our first witness Mr. J. L. Atwood, president of North American Aviation. A number of members of the committee and I have visited the North American plant in Los Angeles. We visited the Rocketdyne plant 2 years ago to observe some tests you were making. We appreciated the courtesies you extended to us at that time.

We know the interest of North American in aviation and space. Someday, perhaps, you will find it appropriate to attach the word "space" to the name of your company.

We are delighted to have you here this morning and I suggest that you proceed with your prepared statement. Following that, we will ask you some questions.

STATEMENT OF J. L. ATWOOD, PRESIDENT OF NORTH AMERICAN AVIATION, INC.; ACCOMPANIED BY HARRISON STORMS, VICE PRESIDENT AND CHIEF ENGINEER, LOS ANGELES DIVISION

Mr. ATWOOD. Mr. Chairman, may I introduce Mr. Harrison Storms, vice president and chief engineer of our Los Angeles division, who is accompanying me here. He will assist me and help me in answering questions.

The CHAIRMAN. If you have anyone else you wish to sit with you, it will be all right.

Mr. ATWOOD. I have no one else, thank you.

Gentlemen, North American Aviation is pleased to take part in these hearings on the possibilities of commercial supersonic air transportation. We have given this subject, including both its economic and its technical aspects, considerable attention and study. We have had wide experience in the technology of advanced supersonic manned flight, including the design and construction of the X–15 research vehicle that will achieve speeds in the vicinity of mach 6, and the design and current manufacture of the B–70 mach 3 intercontinental bomber. Because of its size, speed, and range, the B–70 represents a level of technology that will be of fundamental importance to a supersonic transport. For these reasons, we believe we can contribute information that will be useful to the committee.

Before going into detail on this subject, I would first like to summarize our opinions and general conclusions concerning the development of a supersonic transport for commercial use throughout the world.

(1) The next major improvement in commercial air transportation will be an airplane of intercontinental range, flying at speeds near mach 3. I believe that when this airplane is developed, it will represent a capability of air transportation within the terrestrial atmosphere that will not be superseded economically by a faster aircraft for a great many years.

(2) The triplesonic transport, properly optimized, will be a safe, economical, and commercially profitable means of transportation, provided we exercise the same sort of care and prudence that characterized the successful development of the present subsonic jets.

(3) We should gain a firm basis of experience in long-distance mach 3 cruising operation before attempting to devise a detailed design or complete specifications for the triplesonic commercial aircraft.

(4) Such an optimized commercial transport can be available with effectiveness and reliability in the 1966–70 time period.

Now, it is very important in the design of such an aircraft that all factors be carefully analyzed and interlocked in order to achieve operating suitability and economy. Among these factors are:

Safety and reliability requirements.
Desired range.
Optimum size and capacity.
Operational characteristics.
Sound abatement.
Operating economy.
Flight management and traffic control.

Landing field characteristics and requirements.
Maintenance and utilization characteristics.

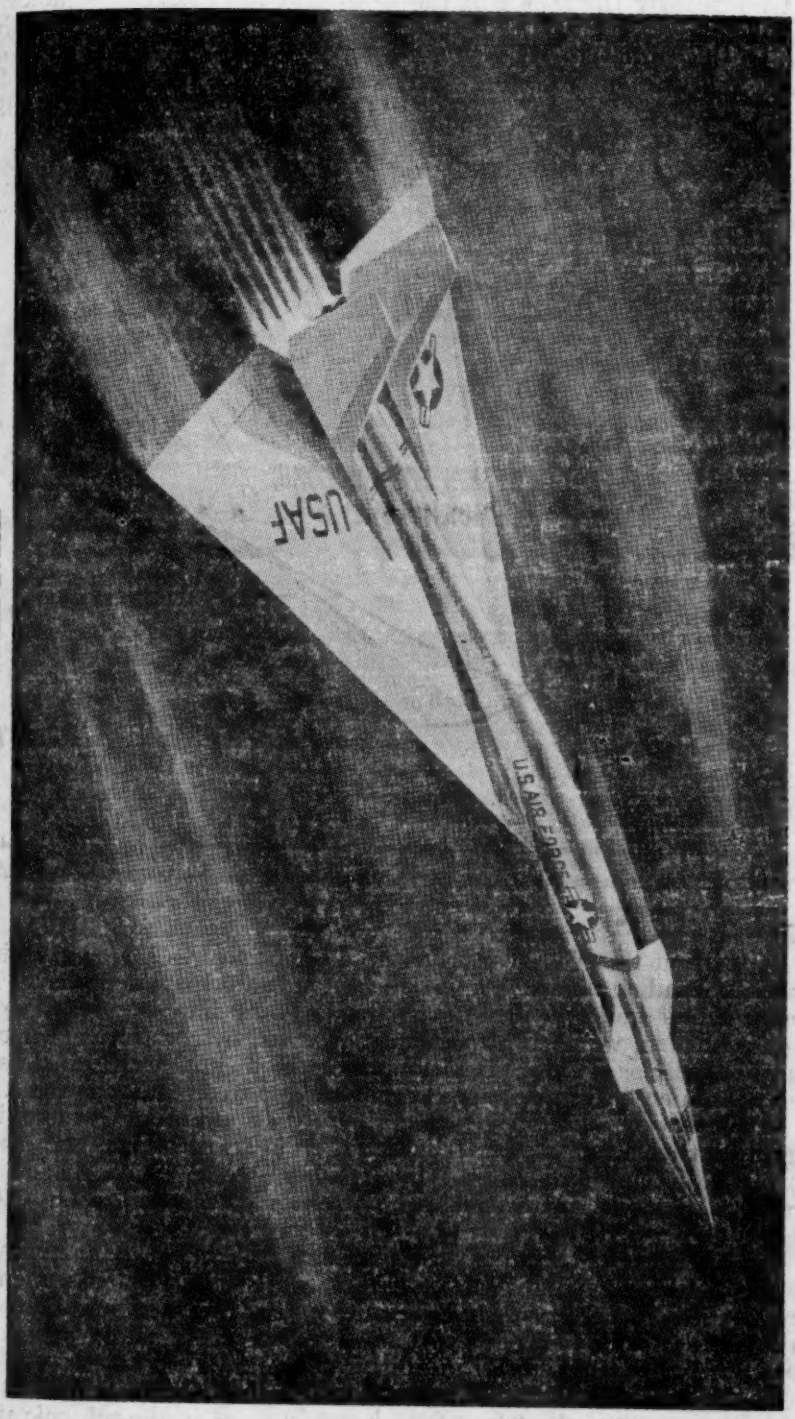
These factors are interrelated in a most complicated fashion, involving technical, economic, and practical considerations of great consequence in the optimum design. On some of them adequate information is now available. On other points, more experience is needed.

In discussing the possibilities of commercial supersonic transportation, the first consideration is what degree of supersonic operation do we want; and second, do we have the basic scientific knowledge to achieve it. The advanced state of the B–70 (fig. 6) program provides an answer to both these considerations.

We display the general aspect of the B–70 in this picture.

The new technology of sustained supersonic cruise for an aircraft roughly comparable in size and gross weight to a supersonic transport has been developed in the B–70 intercontinental bomber program. So far as the air vehicle is concerned, this program is already moving from the developmental phase to the manufacturing phase. Structural design and manufacturing techniques have been developed. The release of engineering drawings for the manufacture of structures and components began last December. The J93 engine, designed and produced by General Electric, has undergone intensive test runs as a complete engine. Detailed subsystem evaluation is underway.

The B–70 program provides the advanced supersonic technology that is directly applicable—in fact, is essential, to the development of a practical and economically competitive supersonic transport. Due to the changes in payload and operating requirements, the B–70 is not considered to be directly convertible to a commercial transport. However, the major design advances of the B–70 will have to be incorporated in such a commercial vehicle, because they are necessary in achieving efficient and economic operation. Of vital importance is the technical knowledge and experience that is being gained in the development and production of advanced supersonic vehicles; for example, North American has accumulated more than 14,000 hours of wind tunnel test time in development of the air vehicle. This body of knowledge and experience will continue to enlarge through the manufacturing, flight testing, and operational stages of the B–70 program—providing an indispensable technological base for development of a supersonic transport.



THE B-70 INTERCONTINENTAL BOMBER

FIGURE 6

Undoubtedly the aspect of the B–70 that has the most significant bearing on commercial supersonic transportation is the advance in the state of the art that allows it to cruise at a speed of mach 3 (fig. 7), or 2,000 miles per hour at an altitude of over 70,000 feet. In the technology of 5 years ago, at the start of the B–70 studies, it was generally understood that when aircraft were pushed from subsonic to supersonic speed, increased drag and sharply increased fuel consumption placed a severe penalty on weight and range. It was at that time believed impratical to achieve intercontinental range with continuous supersonic cruise.

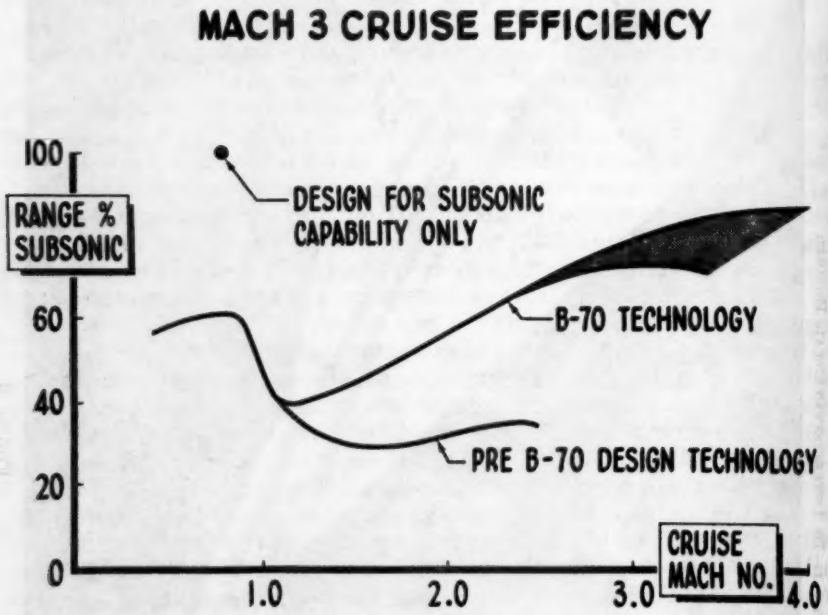


FIGURE 7

Subsequent research has turned up design features that greatly increase the advantage of supersonic flight, showing an optimum in the present state of the art at mach 3. The most important of these is a phenomenon, which was originally observed by the National Aeronautics and Space Administration, and which significantly increases aerodynamic efficiency at speeds equal to or greater than mach 3.

In connection with this chart, I should like to indicate some of its significant aspects. You will notice the dot in the upper left-hand corner indicating the range and speed of a long-range subsonic aircraft. The range corresponds to 100 on our scale at the left—100 percent, if you will.

Now, before the B–70 design technology was perfected, an aircraft designed for supersonic speeds—such as the F–100 fighter—suffered greatly in its range capability because it was designed for what we call the split mission. To begin with, its subsonic range was only about 60 percent of what it might have been if it were designed for subsonic speeds alone. In the supersonic range it was up to only some 30 percent of what we might have achieved in the subsonic airplane, because of increased fuel consumption and other factors.

You will notice the line marked "B–70 technology." Now, here when this line passes mach 1, we do suffer a range degradation but, as we increase the speed, we begin to get the range back.

When you come to the shaded area shown in the upper right-hand part of the chart, the lower line represents what we feel we are able to do today with existing materials and techniques, as we have applied these to the B–70 design. This indicates that when we materially exceed mach 3 our range begins to drop again. This is primarily because of temperature effects which greatly increase the weight of the airplane itself.

The upper line above the shaded area might be described as the target for future evolution. As new materials are developed and invented, and as we master this heat problem, over the years we might aim at the upper line. We are not ready to do that yet, but we set that forth as a rather technological target.

Thus, you see, we might increase range up to mach 4, possibly, before we start to drop again. But I do not offer that as a present capability.

With those remarks on the chart, I will proceed, if I may.

Through this and other developments, Air Force intercontinental bombers will make an unprecedented jump in performance from the subsonic cruise of the B–52 and B–58, bypassing mach 1 and mach 2, to the mach 3 cruise of the B–70. Moreover, the B–70 has been designed to accept advancements in the state of the art that would provide even higher performance.

Our studies indicate that these conclusions should apply equally well to the supersonic transport. That is, a supersonic commercial transport built to cruise in the vicinity of mach 3 would be the most advantageous for airline operations. To illustrate this, we will start by showing the effect of performance advances on aircraft takeoff weight (fig. 8).

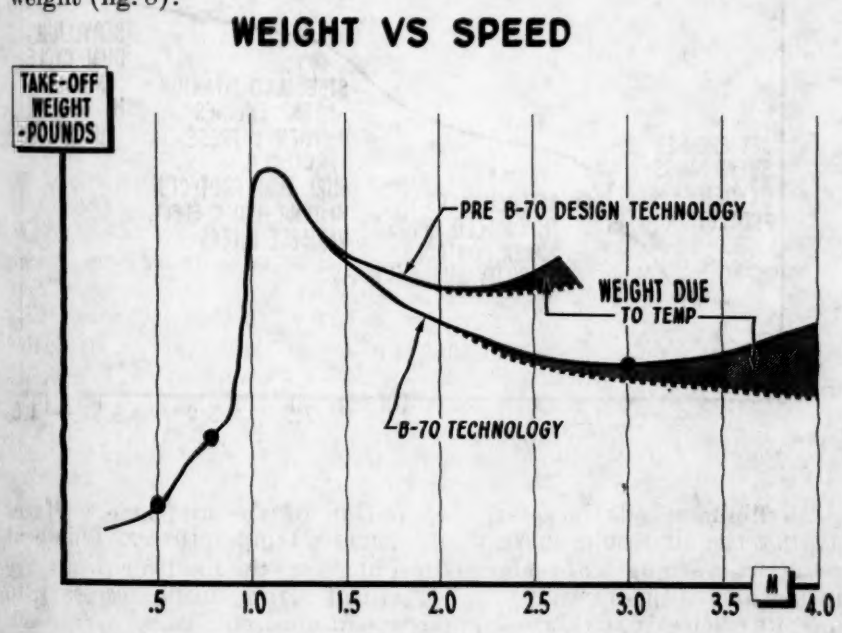


FIGURE 8

An air vehicle designed to cruise subsonically, such as either the DC–7 or Constellation, has the lowest gross weight for the range and payload required. The step to the 707 and DC–8 has been bought at a weight penalty. Past experience and technology indicated that to fly substantially faster than these airplanes would reflect an exorbitant weight increase. Faster airplanes would be limited by the heat barrier to speeds approximately equal to two times the speed of sound.

However, the technologies now being incorporated in the B–70 tend to postpone the expected adverse effects of increasing temperature, so that the necessary weight is only a little greater than that of the subsonic vehicles. The gain in takeoff gross weight at supersonic speeds is due primarily to the increased fuel required as the speed of sound is reached and surpassed. However, as speed is further increased, this effect is minimized by the increased cruise efficiency at higher speeds.

At the same time we recognize that the sophistication of the machine is steadily increasing to accommodate these advances in technology.

The advent of jet engines, swept wings, and associated design requirements has increased the cost of subsonic aircraft (fig. 9). In the same manner, thinner wings, complex structures, supporting systems, and their developments increase the cost of supersonic vehicles. There is, however, a significant difference in this picture which is caused by the so-called heat barrier.

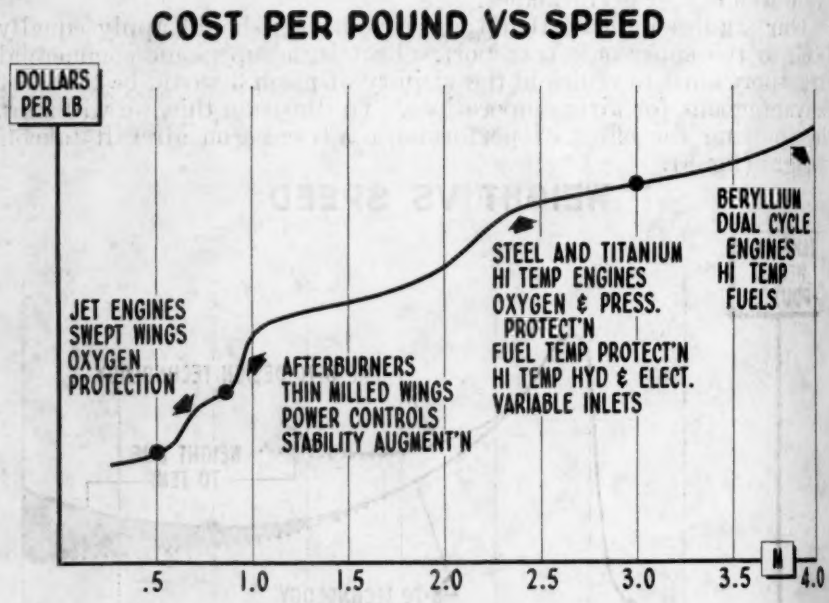


FIGURE 9

As flight speeds increase, the friction of the airframe surfaces against the air results in very high surface temperatures. This heat reduces the strength of materials and increases the need for protective insulation. Consequently, the structural arrangement necessary to operate efficiently in this new environment must change between mach

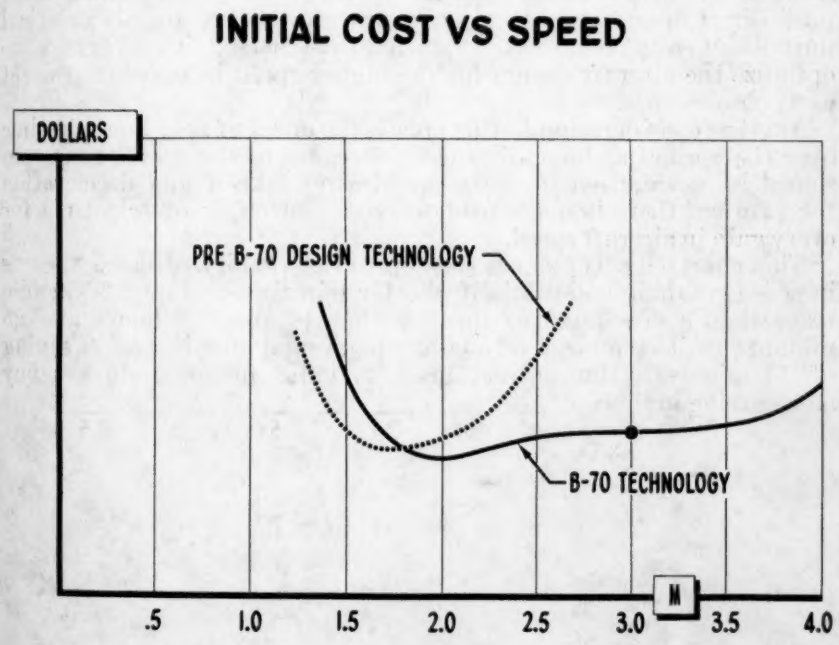
2.0 and 2.5. A supersonic transport system committed to conventional structural technology would therefore be limited to cruise speeds not much higher than mach 2. But a transport based on the technology established with the B–70 would be able to travel at mach 3, and would have a growth potential to higher speeds.

The heat at this speed also requires new development in equipment, seals, glass, fuel, cabin comfort, and so forth. Solutions to these problems have already been developed for military requirements in the B–70 program; more will have to be developed for the commercial transport, and the flight-test program of the B–70 will provide substantial data for these solutions.

But it should be noted that basic mach 3 developments provide a wide plateau where only minor increases in complexity are necessary to achieve substantially greater speeds. Therefore, a broad future of growth and utility can be predicted for types designed from the new mach 3 technology, as opposed to the limited future of mach 2 types.

I would like to comment further on the chart entitled "Cost Per Pound Versus Speed." I do not offer it as a precise estimate of what the cost will be in dollars per pound. As you will note, we have put no vertical reference scale on the left-hand side. This might be considered as a trend chart, so if you will consider it in that light I would appreciate it. We expect the cost per pound to increase at some ratio in approximately the manner delineated here. We do not know the precise amounts.

Now, let us consider the effects of the last two charts together. You will recall these charts showed, respectively, the increase in weight as the speed went higher, and the increase in cost per pound. If you put cost and pounds together, you have this next chart (fig. 10).



FIUGRE 10

We observe that for either the conventional design or the new technology, total cost for the supersonic vehicle shows a low point near mach 2. But, significantly, the new technology represents a minor increase in investment for a major gain in performance above that speed for approximately one and one-half mach numbers.

Our estimate is that the cost will not increase materially from the low point at mach 2 until well beyond mach 3.

The lessons to be derived from these considerations are:

(1) A supersonic commercial transport committed to aluminum technology and existing high pressure ratio engines is limited to performance in the vicinity of mach 2. It has no growth potential to meet competition from another commercial transport built with more advanced technology. Another country could effectively outmode it with a transport cruising at mach 3.

(2) The mach 3 structural and engine technology is an accomplished fact today. A triplesonic transport is not only feasible but its 50-percent increase in performance can be achieved at only slightly greater initial investment.

(3) Such a mach 3 commercial transport would be on the threshold of new performance capabilities. It could not be outmoded by another aircraft for a great many years. On the other hand, it would enable this country to outmode the transports of any other country that had committed its supersonic transport program to the lower supersonic speeds.

In addition to the advantage of mach 3 speed from the standpoint of initial investment costs, there is also marked advantage in relation to airline operating conditions and costs. Studies indicate that direct operating costs per passenger mile remain about the same for mach 2, mach 3, and slightly faster. Beyond that, at least within the present state of the art, requirements for propulsion and air conditioning push direct operating costs sharply upward. Since for all practical purposes it costs no more to go mach 3 than mach 2, it makes sense to optimize the aircraft design for the higher speed in order to prevent early obsolescence.

Another consideration in this area is the effect of speed on trip time over the normal airliner distances. Because of the travel time consumed in acceleration to cruise speed after takeoff and deceleration for landing, there is not a proportional shortening of trip time for every gain in aircraft speed.

This chart (fig. 11) shows that up to the vicinity of mach 3, gains in speed result in substantially shorter trip times. For a 3,750-mile transatlantic crossing, the mach 2 time is about 3 hours and 25 minutes, while the mach 3 time is 2 hours and 40 minutes—a saving of 45 minutes. But beyond mach 3, gains in speed do not buy much saving in time.

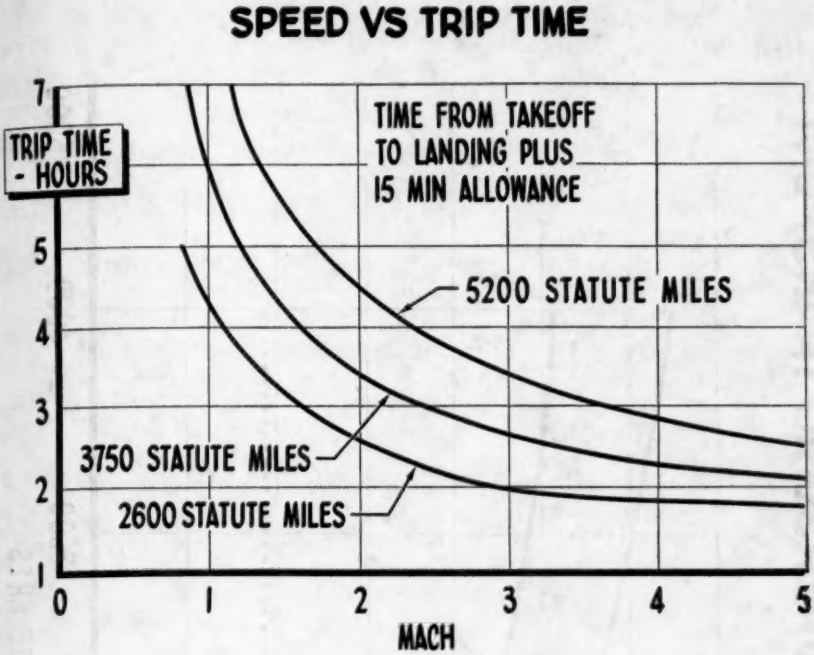


FIGURE 11

For example, the mach 4 time is only about 20 minutes shorter. The advantage of speed does become more important over longer hauls, but considering only conventional routes, reducing trip time would appear to be worth the technical effort of increased speed only up to the vicinity of mach 3. Above this, it becomes increasingly questionable whether the narrowing advantage is worth the price.

Such considerations tend to show that mach 3 provides a plateau of commercial performance that is not likely to be superseded in the foreseeable future. While commercial aircraft of slower speeds would be likely to be outmoded quickly by a mach 3 aircraft, the latter promises to maintain an extremely long service life and a long amortization period.

Now, whether we expect to travel at mach 2, mach 3, or mach 4, we must satisfy ourselves that it can be done at operating costs that would be profitable to the airlines. To discuss such operating costs at this early date is admittedly risky, since for reasons that I will outline in a moment we do not yet know all the design details of a supersonic transport. It should therefore be understood that any costs discussed at this time must necessarily be contingent on several uncertain factors.

One of these, for example, is the availability of efficient engines with acceptable sound levels for a large transport of, say, 130 to 150 seats. At best, the sound problem is of major consequence, and hence this factor cannot be lightly dismissed. However, if certain assumptions are accepted for the sake of discussion, we would like to present some rough estimates of the cost of operating a commercial supersonic transport fleet (fig. 12.)

HIGH PRODUCTIVITY OF SUPERSONIC TRANSPORT

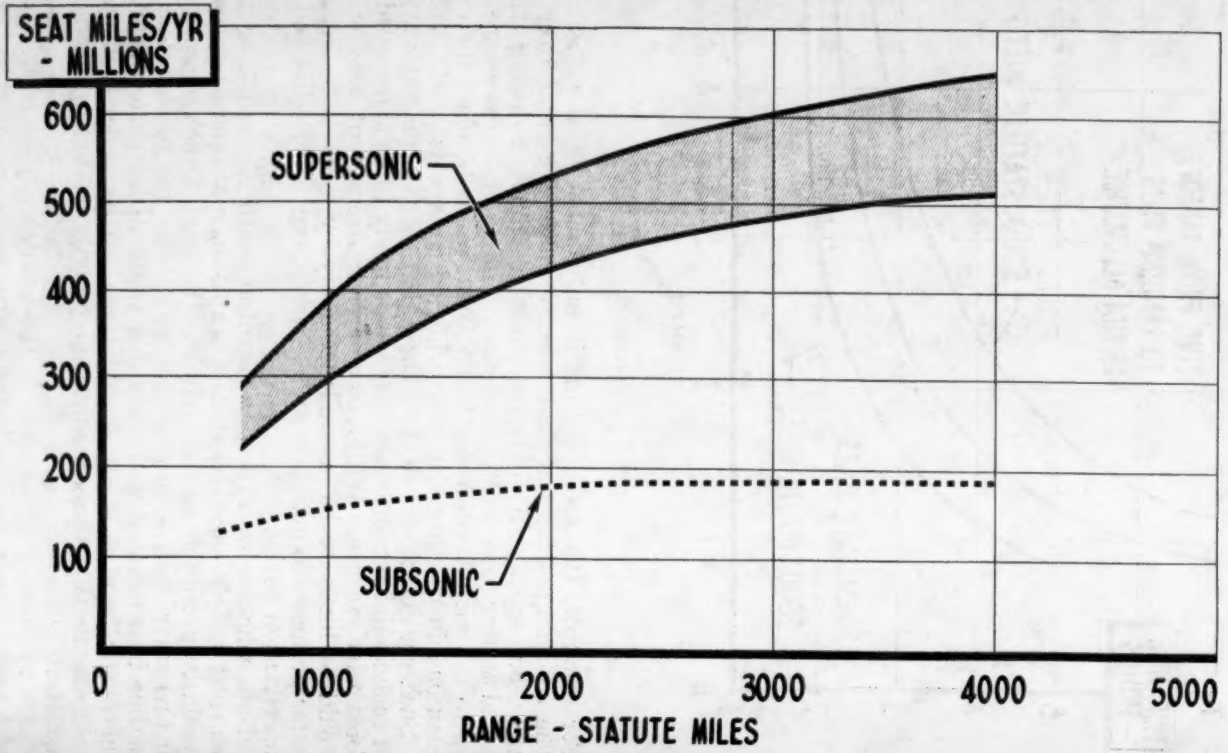


FIGURE 12

Of primary importance in the economics of the supersonic transport is that its great speed enables it to make substantially more trips in a given period of time than the subsonic transport. This chart offers a means of measuring this supersonic advantage by the number of seat-miles traveled in a given period of time, or what is known as productivity.

For purposes of this and the next two charts, this shaded band represents a span of estimates ranging from a 118-passenger to a 150-passenger mach 3 transport. In comparing these with a typical present-day subsonic jet transport, we have applied in both cases the average utilization of 3,000 hours per year designated by the Air Transport Association.

If this were divided into trip distances of 1,000 statute miles, the subsonic jet would produce approximately 160 million seat-miles per year, while the mach 3 transport would produce somewhere between 300 and 380 million seat-miles—of course, at an increased initial investment. While the mach 3 transport is roughly twice as productive for this short distance, the difference is even more dramatic for the longer ranges. At 4,000 statute miles the subsonic transport's productivity is only 185 million seat-miles, while the mach 3 aircraft's productivity is between 520 million and 640 million.

At this distance, assuming that fares and load factors were comparable, the mach 3 transport would produce roughly three times the annual revenue of the subsonic jet. This is the principal reason why, according to our studies, the commercial mach 3 transport could absorb a much larger development and manufacturing cost, and also a somewhat higher direct operating cost per seat-mile if that appears likely, and still be able to show a higher net return per dollar invested than the subsonic jet transport.

This may be graphically demonstrated by comparing the productivity per dollar invested in the supersonic transport and the subsonic transport (fig. 13).

This chart again shows a 118-passenger hypothetical design and a 150-passenger design, at costs estimated in accordance with the general curves we have shown you before.

Again, recognizing the uncertainties within which we are working, studies to date suggest that the annual seat-miles per dollar invested will be substantially higher for the commercial mach 3 transport than for existing subsonic jet transports. The comparison is shown here for various load factors—that is, the average percentage of seats filled by passengers. At a load factor of 60 percent—certainly a conservative figure for either subsonic or supersonic jets—we find that each dollar invested in a mach 3 transport is expected to produce between 23 and 25 annual seat-miles. This may be compared with about 17 seat-miles per year produced by each dollar invested in the subsonic commercial transport at a similar load factor. The differential in favor of the commercial supersonic transport becomes greater as the load factor increases, as may be seen.

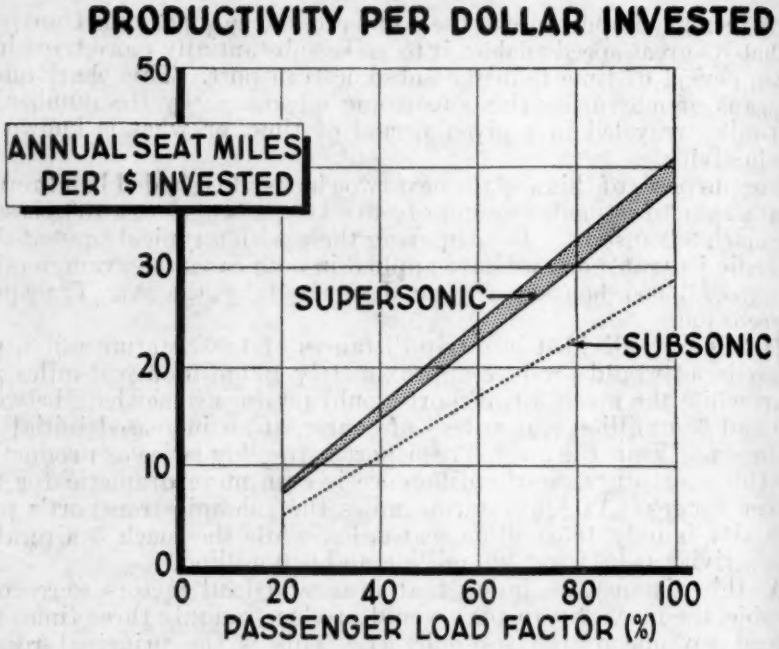


FIGURE 13

To give more significance to these figures we must, of course, consider direct operating costs per seat-mile (fig. 14).

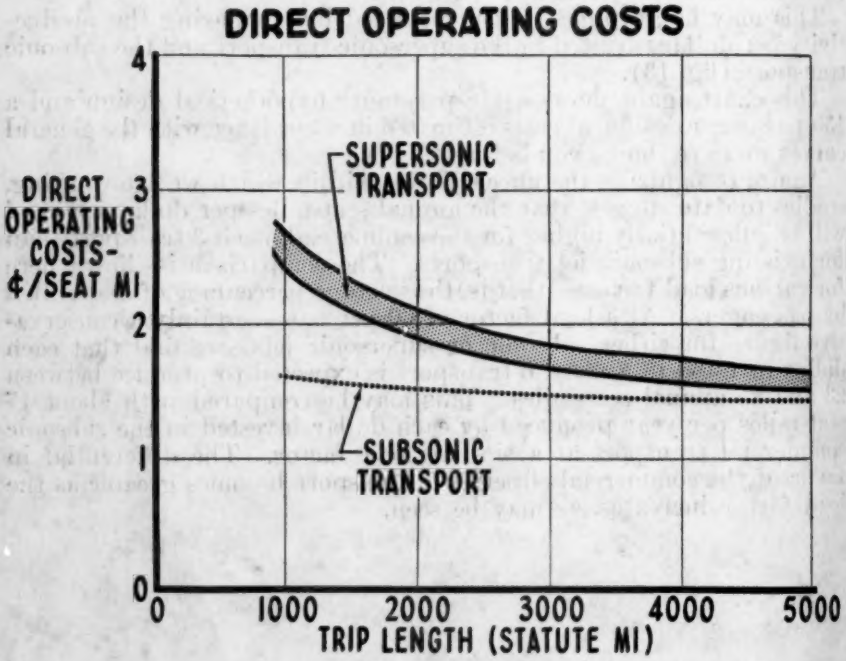


FIGURE 14

The figures used to arrive at the direct operating costs shown here include the costs of crew and fuel at international rates, maintenance, insurance, and depreciation on the initial aircraft investment. They also give the subsonic jet the benefit of a 10-percent improvement in fuel consumption through better engine performance by the year 1968.

Available data indicate that these costs for the current subsonic jets fall along this relatively flat curve. The direct operating costs of the triplesonic transport would, of course, depend to a great degree on seating capacity. To give a rough measure of comparison,we have plotted our estimates for a 118-passenger and a 150-passenger triplesonic transport as the two extremes of this band.

Several conclusions can be drawn from these comparisons: Given the same seating capacity and range, the cost per seat-mile of the mach 3 transport is not expected to be as low as that of today's jet transports. However, the direct operating costs of triplesonic transports on the order of 150 seats are expected to approach those of the current subsonic jet transports over the longer hauls. It is conceivable that even larger supersonic transports would have lower operating costs than those of today's jet transports, especially at longer ranges.

The lower line of the shaded band represents the 150-passenger transport and the upper line a 118-passenger transport, as indicated before. It is noteworthy, of course, that these lines tend to converge with the subsonic transport line at ranges of 4,000 to 5,000 miles.

Now, our estimates are not complete, as I indicated before. These representations are somewhat crude. However, it is significant that here, the difference in cost is on the order of a quarter of a cent per seat-mile. We cannot indicate a cost saving on the supersonic transport, but the difference will be very small.

The CHAIRMAN. Meaning a difference of about one-quarter of a cent per seat-mile increased by use of the triplesonic jet.

Mr. ATWOOD. That is the best estimate we can give you today.

It should be realized that supersonic flight may open the door to longer commercial runs. One of the reasons they have not been scheduled heretofore is that, in the past, passengers have tended to resist the discomfort associated with flights of long duration. But with triplesonic speed, such distances can be covered in an extremely short time, eliminating this objection. Just as the present subsonic jets generated new traffic of their own because of their increased speed, so the mach 3 transports may be expected to open up many new attractive and profitable flights in which they would show more economical seat-mile operation than the subsonic aircraft.

Having discussed with you the advantages and feasibility of a commercial transport speed of mach 3, including the economic factors pointing to profitable operation at that speed, I would like now to explore the prospects of achieving such a transport within this decade.

As I pointed out earlier, the technical invasion of this performance regime began in 1955, when we started design studies for the B–70 intercontinental bomber. By now, 5 years later, we have resolved the basic engineering problems associated with sustained mach 3 cruise in large air vehicles. This includes not only the aerodynamic and structural features providing efficient cruise at this speed, which I have already discussed, but a number of other design elements that must be incorporated in a mach 3 transport for safe and practical operation.

Among these is the placement of the engines near the centerline of the airframe. Early in our studies, it was obvious that podded arrangement of engines on the wings offered unacceptable drag penalties at advanced supersonic speeds. In addition, failure of a podded engine situated some distance outboard of the fuselage accentuates the accompanying loss of power and the increase of drag. If this occurred at supersonic speed it could cause a violent yawing motion that would jeopardize the safety of the airplane. But in placing the B–70 engines in parallel at the rear of the fuselage we greatly reduce drag and increase safety.

Another important technological advance in the B–70 is the environmental control system, which regulates cabin air pressure and temperature at altitudes up to and above 70,000 feet. For the first time, Air Force crews will be able to shed heavy, cumbersome suits and oxygen masks, and to enjoy shirt-sleeve conditions comparable to those on commercial transports.

These are, of course, only a few highlights. A whole range of problems associated with high temperatures at mach 3 speed have been resolved. Possibly even more significant, we have gained the engineering and manufacturing experience necessary to integrate all of these new technologies into a military aircraft of advanced performance. Vital knowledge in this new performance environment will continue to be gained in the program, so that by the time the extensive flight-test program is completed, the Nation will have a mach 3 intercontinental bomber that will obsolete existing Soviet defenses and the technology on which they are based.

Although the scientific knowledge achieved thus far is directly applicable to a mach 3 commercial transport, we must recognize that the requirements of such a transport are different from those of a bomber. The design of any aircraft represents a series of tradeoffs or compromises between a number of factors, such as increased performance on the one hand, and the cost of achieving this performance on the other. It is one thing to design an aircraft for military use, in which national security and the survival of the crew depend upon maximum performance in terms of speed, range, altitude, and payload—sometimes at the expense of operating economy. It is another thing to design a commercial aircraft that must not only assure the safety of the passengers, but operate within the framework of worldwide air traffic, and at a profit. Let me touch upon a few of the areas requiring additional development effort to achieve a supersonic transport optimized for commercial use.

The area probably requiring the most engineering effort is that of sound control. Residents near air terminals have been disturbed by two major types of sound from the current subsonic jet transports—compressor whine in the approach flight path and jet exhaust noise in the takeoff flight path.

Compressor whine is not expected to be a serious problem with mach 3 transports. Various design factors for efficient mach 3 flight call for long engine air inlet ducts, which make the whine highly directional and confine it to a narrow angle straight ahead of the aircraft. Because of the characteristic attitude of the supersonic-type air vehicle in making its landing approach, this sound direction would be slightly upward, rather than toward the ground.

On the other hand, jet exhaust sound in the takeoff flight path is a function of exhaust velocity; that is, greater velocity means more sound potential. After studying several types of engines, we have concluded that the turbofan engine, with its lower exhaust velocities, shows the lowest sound potential. Further reducing this sound to acceptable levels through sound suppression devices, while still providing the necessary thrust levels, appears to be feasible.

Still another sound problem area is that of sonic boom. The effect of sonic boom on the ground is materially reduced as the altitude of supersonic aircraft is increased. Because the natural cruise altitude of a mach 3 aircraft is much higher than that of a mach 2 aircraft, whatever difficulties would be experienced in this area would be less at mach 3 than at mach 2.

These sound control problems, in turn, bear upon the flight path of the aircraft, which in turn influences fuel economy. It is not difficult to see the complicated interrelation of these factors, many of which are yet unknown, and others of which exist only by theoretical calculation. Not until we have actual experience in longrange mach 3 flight by a large air vehicle will we be able to get firm answers that will permit the design of an optimized supersonic transport.

In addition to these practical aspects of supersonic transportation, we feel that the most careful thought must be given to the safety implications in transporting passengers at the speed of a bullet and at altitudes as high as 70,000 feet. An unprecedented degree of reliability will most certainly be built into an aircraft of such performance. For example, alternate modes of air conditioning will be incorporated to guard against possible failure of the primary system. While such high safety factors naturally increase the weight of the vehicle, we believe they will be achieved without noticeably compromising its performance. Certainly a critical factor in arriving at such solutions will be the actual flight experience at these unprecedented altitudes to be gained with the B–70.

In approaching such performance factors, we can calculate the type of equipment that we will need, but we cannot be certain that our calculations are correct until we have considerable test and operating experience in the actual performance environment. I think you will agree that if you ask me to draw you a map of an uncharted region, I can go up on a hill and take a look at it from a distance, but I can draw a much better map after I have been over the ground. For this reason it would be unrealistic—in fact wasteful—to make a complete design for a commercial supersonic airliner until we have flight test and other operating data that will be available from the B–70 program.

There is little point in spending large amounts of money to design a commercial supersonic transport, only to turn around and redesign it later on the basis of critical data to be received from the actual operation of an airplane of comparable speed, size, gross weight, and range. In fact, it is my belief that the economic feasibility of a supersonic transport program is strongly affected by the degree to which it would draw upon the technology and operational experience established in the B–70 program.

But in addition to the advantage of cost, I would like to emphasize the prudence of an ordered approach (fig. 15).

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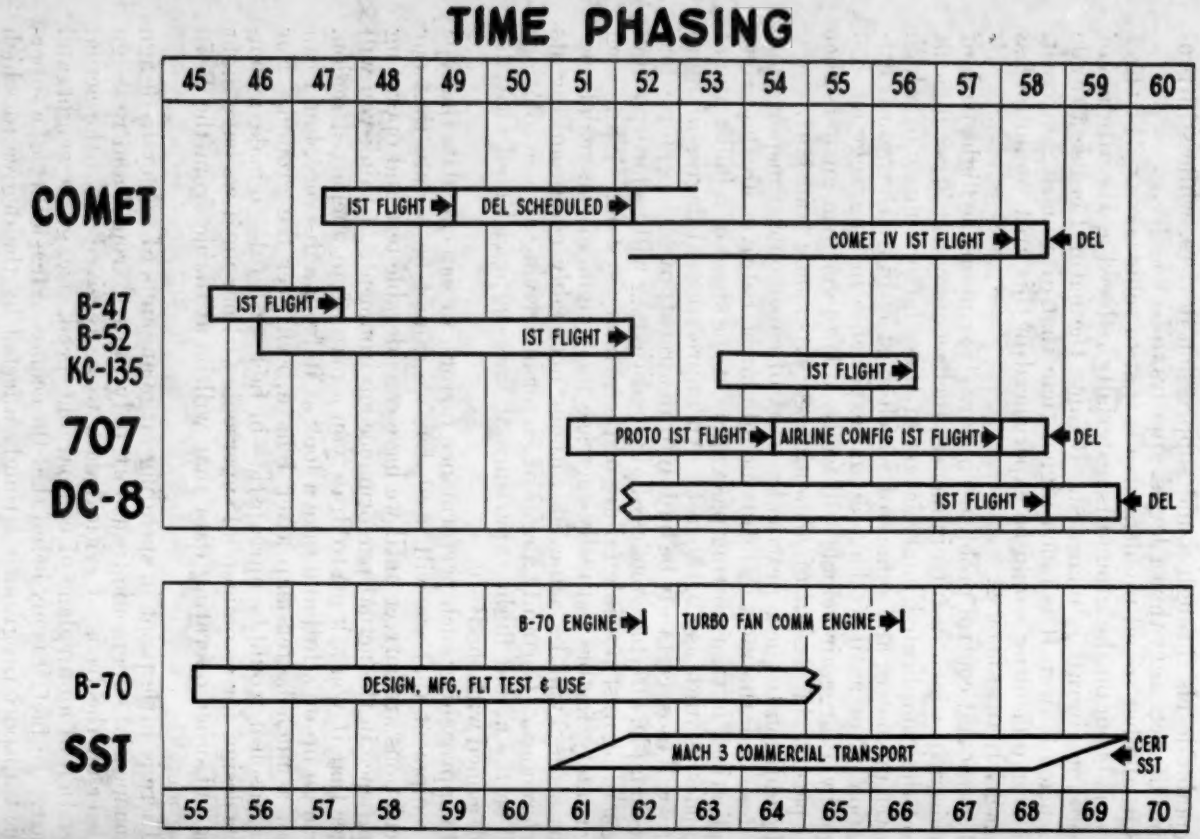
TIME PHASING
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COMET
IST FLIGHT
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707
PROTO IST FLIGHT
AIRLINE CONFIG IST FLIGHT
DEL
DC-8
IST FLIGHT
DEL
B-70 ENGINE
TURBO FAN COMM ENGINE
B-70
DESIGN, MFG, FLT TEST & USE
SST
MACH 3 COMMERCIAL TRANSPORT
CERT SST
55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70

FIGURE 15

The information for this chart was drawn from a number of sources outside of company records, but I believe it is reliable for demonstration purposes.

After World War II the British began developing what was the earliest sweptwing jet transport, the Comet. It flew 2 years before the first flight of a prototype of the V series of British sweptwing bombers. The Comet, therefore, had to take on its own shoulders practically all of the flight test and operational experience in this new regime. I need not detail the disaster that overtook the Comet in airline operations in 1953. Not until 1958 was an improved and larger capacity Comet firmly established on the airways. The point is that a broader base of operational experience in near-sonic jet flight would have given the Comet more assurance of timely commercial success. The Comet program could either have done so itself, at considerable expense, or it could have drawn more heavily upon the operational experience of military aircraft, at much less cost.

In the United States the development of large sweptwing jet aircraft began with the initiation of design for the B–47 and the B–52 right after World War II. The B–47 had actually been flying for nearly 3½ years, providing invaluable technical data on advanced subsonic jet flight of large aircraft, when preliminary design was commenced on what was to be the 707 in 1951. The next year the prototype of the B–52 was first flown. Following this, a prototype of the KC–135 jet tanker, whose configuration was close to that of the 707 design, was flown in mid-1954. All of this background in jet propulsion, materials and processes, and the aerodynamics of near-sonic flight, went into the final design of the 707, which was first flown in February 1958, and began airline operations a year later. I might add that the DC–8 was able to draw upon the development, manufacturing and flight experience of the Navy A3D bomber and the Air Force RB–66 reconnaissance bomber, which operate in the same performance field, as well as upon the general experience of the Air Force in operating the B–47, B–52, and KC–135.

FIGURE 15

There was, in short, a large body of practical experience and technical knowledge gained in actual military operation of large jet aircraft that not only proved out the feasibility of such flight, but its safety and economic practicality for commercial operations.

Having expressed the need for caution in the logical development of a supersonic transport, I would now like to point out that such a course would still permit a mach 3 commercial airliner to come into service close to the dates that have generally been mentioned by airline officials. In part of figure 15 we show the development which has already been completed in the mach 3 cruise performance regime, will continue so far as the B–70 military bomber is concerned, and which can include development of a mach 3 commercial transport.

This bar represents the B–70 experience, including development, manufacturing, and flight experience, beginning with inception of design studies in mid-1955, and contract go-ahead in 1957. I am not at liberty to discuss the first flight date of the B–70 in open session because of security considerations.

The second bar represents our estimate on the development of a triplesonic transport from the start of production engineering through full FAA certification. You will notice that this bar has variable

beginnings and endings because we could assume the earliest beginning might be in early 1961, and if that were possible the certification could take place some time in 1968. On the other hand, if the start were made in the middle of 1962 we would estimate it would be the first of 1970 before certification could take place.

This chart, which shows a reasonable go-ahead date of 1961 or 1962 for a commercial supersonic transport program, does not imply that nothing should be done now. On the contrary, North American itself has for the past 2 years been conducting research on optimum commercial requirements, route studies, passenger capacities, utilization, scheduling, and so forth, and is continuing to do so.

If the Nation feels its best interests would be served by assuring that it will achieve what has been called a "supersonic transport soonest," with other than commercial benefits, an effective aircraft of limited passenger or cargo capacity for this purpose could be produced in the quickest time and at the least cost by a minimum modification of the B–70. This would mainly require the substitution of passenger seats in the space now designed for military electronic equipment and fuselage fuel tanks. Such an aircraft could be made available early in the production phase of the B–70 program.

To summarize our presentation, we believe that:

(1) The next major improvement in commercial air transportation will be an airplane of intercontinental range, flying at speeds near mach 3. When this airplane is developed, it will represent a capability of air transportation within the terrestrial atmosphere that will not be superseded economically by a faster aircraft for a great many years.

(2) The triplesonic transport, properly optimized will be a safe, economical, and commercially profitable means of transportation.

(3) We should gain a firm basis of experience in long-distance mach 3 cruising operation before attempting to devise a detailed design or complete specifications for the triplesonic commercial aircraft.

(4) Such an optimized commercial transport can be available with effectiveness and reliability in the 1966–70 time period.

Gentlemen, we have been most happy to contribute this presentation to your important studies, and if there are any areas that you would like to explore in more detail, we will attempt to answer your questions.

The CHAIRMAN. Thank you very much, Mr. Atwood, for a very fine, comprehensive and detailed statement.

We have one more witness this morning, Mr. R. C. Sebold, of Convair. We had also scheduled Mr. Hall Hibbard, vice president of Lockheed. We are informed that he is ill this morning and is unable to appear. I have been talking to counsel and we will probably reschedule his appearance for next week, if it is all right with him. In doing so, we might also add one more witness from the Air Force. The Air Force may be interested in bringing the committee a little better up to date on the progress made in the B–70 program.

Mr. Atwood, this thing seems to tie in with the B–70 program at every turn, doesn't it?

Mr. ATWOOD. Yes, sir. This is our frame of reference primarily, Mr. Chairman, and we think it does tie in.

The CHAIRMAN. Does it tie in with the B–58, the Hustler? I understand we had one in the armed services program the other day at Andrews.

Mr. ATWOOD. I am sure it does. I think Mr. Sebold at Convair, the makers of the B–58, can tell you about it. He is in a better position to speak on that subject.

The CHAIRMAN. In your statement you say

"if the Nation feels its best interests would be served by assuring the development of the supersonic transport soonest, et cetera.

What is your own view? Is it to the national interest that we undertake to develop the supersonic or triplesonic transport?

Mr. ATWOOD. Mr. Chairman, I don't feel that my position gives me a perspective which provides an advantageous view in that regard.

I have pointed out that to make the proper commercial transport would take considerable time and should not be done impulsively because it probably will run into trouble and will have to be done over again.

I meant by that statement concerning the supersonic transport soonest, that the B–70 structurally could be made into a transport which would look very much like the ultimate supersonic transport externally.

I have further pointed out that I realize it would not be economic in that configuration. I think it would add considerably to our experience, but I believe that the B–70 alone, with or without that change, would provide the base of experience we need for supersonic transport design.

The CHAIRMAN. Now, in handling the 707, we didn't proceed from the development of the B–52, but we waited until the KC–135 was developed, didn't we?

Mr. ATWOOD. Yes, sir.

The CHAIRMAN. Would you make a change in your recommendations at this early hour regarding the development of the triplesonic jet transport?

Mr. ATWOOD. No, sir, I don't believe so. I think it was perhaps circumstances that led to the KC–135 development before the 707. Perhaps for many reasons; I don't know.

I don't feel that we would have to take all the steps we took before at all. I think we made a good datum point, or starting point foundation.

The CHAIRMAN. You wouldn't recommend any action at this hour, looking toward the organization of commercial interests in this country, toward promoting a prototype for a triplesonic jet transport?

Mr. ATWOOD. Independent of all other work?

The CHAIRMAN. No, related with other work, of course, and related with the development of the B–70 and the B–58.

Mr. ATWOOD. I think both these aircraft, the B–58 and the B–70, are important predecessors to the commercial design. I would not advocate the immediate ordering of a commercial supersonic transport for the reasons that I have outlined.

The CHAIRMAN. Would you suggest that private industry make arrangements for substantial contributions for research and development costs at this hour?

Mr. ATWOOD. Do you mean in a pool, Mr. Chairman?

The CHAIRMAN. A pool or individually.

Mr. ATWOOD. I believe that individually a considerable amount is being expended in this direction, but that is an individual matter. I do not suppose that it should be extended any faster than it is.

The CHAIRMAN. You wouldn't expect the Government to subsidize the entire development, would you?

Mr. ATWOOD. This has never happened before in commercial transports, Mr. Chairman, and I wouldn't expect it.

The CHAIRMAN. Well now, assuming we went ahead with this and in 1966 or 1970 a satisfactory triplesonic jet transport would have been developed; would industry be in a position to purchase and to use such a plane commercially?

Mr. ATWOOD. I do not know, Mr. Chairman. The costs will be great, and this will depend certainly on the resources, intentions, and desires of the airlines.

The CHAIRMAN. Mr. Moeller.

Mr. MOELLER. I would like to state that I think our witness has provided us with an excellent prepared statement.

You made reference to it before, and I would like to refer to it again. This is one of the finest studies we have had brought to our attention.

The CHAIRMAN. It certainly deserves our further study and consideration.

Mr. KING. Mr. Atwood, would you refresh my recollection on the present status of the B–70 to which you have made several references in your statement?

Mr. ATWOOD. Yes, sir, within the security limits that the military have established.

The engineering design is in considerable measure completed for the first prototype, although it is still continuing. Metal is being cut, and the Air Force has on order one prototype. A second prototype is supposedly authorized, but not yet funded.

Mr. KING. Is the B–70 past the theoretical stage and into the stage where you feel that production is feasible?

Mr. ATWOOD. Yes, sir. We feel that all of the performance parameters have been accurately delineated. Wind tunnel tests and structural tests have proved, in the same fashion by which we prove any new aircraft, its performance. The designing for tooling has been perfected, and it is quite certain that the aircraft can be built according to schedule.

Mr. KING. That is all I have, Mr. Chairman.

The CHAIRMAN. To what extent would this airplane, when perfected, render present equipment obsolete?

Mr. ATWOOD. You are speaking of the military version?

The CHAIRMAN. No, I am talking about the triplesonic transport.

Mr. ATWOOD. I feel it would make all long-distance flights obsolete in subsonic aircraft. I do not believe it will obsolete subsonic transportation for distances up to 1,500 miles, or even 2,000.

The CHAIRMAN. How about airports?

Mr. ATWOOD. We expect that the airports as presently designed will be substantially suitable for the supersonic transport.

In this connection we feel that the landing speeds must be very much the same as for the present subsonic jets. Takeoff distances must be

roughly the same and the noise must be brought within pretty much the same boundaries that we consider acceptable today. So we do not expect a complete new system of airports to be required.

The CHAIRMAN. In the development of the prototype is it your view that we should follow the development of the B–70, and rather than encourage the development of two competing types of prototypes, simply follow along in the development and the experience that is gained in the B–70 program?

Mr. ATWOOD. My suggestion, Mr. Chairman, is substantially that. It appears to us that the supersonic transport will look very much the same as the B–70 externally. We feel that the fundamentals are the same. We feel that most of the necessary advances are being made in the B–70 design configuration.

The CHAIRMAN. Would that tend to destroy competitive spirit in the airplane industry?

Mr. ATWOOD. No, sir, I don't think it follows at all that the company which makes the B–70 necessarily makes the supersonic transport. Far from that conclusion—in fact, I consider it a non sequitur.

Actually the information gained here is national information, industrywide information; fundamental things.

The CHAIRMAN. Assuming we went so far as to develop the triple-sonic jet transport and suppose North American should get the contract. Would you advocate an exclusive proposition that other companies should not participate with North American;

Mr. ATWOOD. This is a very interesting topic, Mr. Chairman, and one upon which I have formed no strong convictions. Of course, many companies would participate in the construction of such a transport. I feel no matter how it is financed, however, that someone must be the engineering boss, some organization, and consequently somebody will be the design leader.

It must be, as all major things have to be done, leading up to one point.

The CHAIRMAN. Speaking of a design leader, do you think private industry or an agency of the Government should be design leader?

Mr. ATWOOD. In design it is industry that has had that role and I think will always have it. I notice General Haugen the other day said the Air Force had offered services as executive manager. This could well be. They are executive managers on such things as the Atlas and various other programs. However, the design itself is done by industry and responsibility is delegated to a design manager for the equipment itself. That is my point.

The CHAIRMAN. What is your recommendation as to how we could step up the B–70 program?

Mr. ATWOOD. Sir, I don't believe my comments on that would be appropriate. Of course, we have a strong interest in this program, and it is related to the authorization and funding, very definitely.

The CHAIRMAN. In other words, more money might help. That is a blunt way of putting it, is it not?

Mr. ATWOOD. Yes, sir. This program is——

The CHAIRMAN. There is nothing you can do with your own efforts with the same amount of money to speed up that program. You have the contract. You look to us for money but we look to you for results too.

Can your company produce better results than you are doing now?

Mr. ATWOOD. As you know, the B–70 was a weapon system program. It was cut back to a prototype program last December. It was stated that this would be examined and further analyzed, and the future rate at which the program would be pursued would be determined later. We are awaiting that kind of determination, you might say. I am sure it is being examined very, very carefully.

The CHAIRMAN. That would come from the Air Force?

Mr. ATWOOD. Yes, sir. They are the ones who ordered the aircraft from us.

The CHAIRMAN. Suppose the world suddenly had an operational supersonic jet transport of the type we are talking about here. And suppose that it was produced by the Soviets rather than ourselves. What would be the effect?

You have had experience in the aviation industry. What would be the impact on world thinking and on our own economy?

Mr. ATWOOD. It would be detrimental, Mr. Chairman. If they had failures in this regard through an improper approach or if it were exceedingly expensive, we wouldn't know about it. If they had any successes it would certainly be detrimental in a general sort of way.

The CHAIRMAN. Do you think the impact would be severe in the field of aviation or just a minor, trivial, passing impact?

Mr. ATWOOD. Of course, I don't know, but I think it might be rather great depending on how it was used. If it were used for propaganda flights, it would be one thing. If it were used for actually hauling personnel before we could do it, it might be a severe economic handicap.

The CHAIRMAN. Our recent experience indicates that planes flying at levels of 70,000 or 80,000 feet, as you visualize this plane would fly, are really above antiaircraft fire, aren't they?

Mr. ATWOOD. That is my opinion, Mr. Chairman.

The CHAIRMAN. They would be reasonably safe in the present state of the art.

Mr. ATWOOD. Yes, I think that.

The CHAIRMAN. So there would have to be new inventions to counteract these planes because they could fly all over the world with impunity.

Mr. ATWOOD. I think so, Mr. Chairman, and I might point out that it is our conclusion that air defense is many, many times more expensive than penetration.

The CHAIRMAN. Now, some people are inclined to feel that aeronautical research and powerplant development have suffered because of NASA's present preoccupation with space research.

You are involved in space projects as well as aeronautics. What is your opinion on that?

Mr. ATWOOD. I don't think NASA has neglected aeronautics in any field that challenges the industry or the military in this country. I think, on the contrary, they have supported most vigorously and effectively all the programs that have come up. It is quite true that perhaps there are fewer specific items upon which they would care to work right now, but I consider their support effective and certainly adequate.

The CHAIRMAN. Well, haven't they closed down some wind tunnels and other facilities?

Mr. ATWOOD. Yes, sir. I understand they have closed down——

The CHAIRMAN. Do you recommend that sort of action?

Mr. ATWOOD. The wind tunnel situation in this country has been very interesting. There was a shortage of wind tunnels for quite a while. The industry has provided many tunnels and we had a cooperative industry-owned tunnel at California Institute of Technology. We have had to close that down.

This is only because there are fewer aircraft being developed, Mr. Chairman—fewer different models of aircraft. But I don't think it changes the significance of those aircraft that are being developed—in fact, quite the opposite. I think the significance of those that are being developed perhaps is even greater, but fewer tunnels are required.

The CHAIRMAN. Fewer tunnels; they are larger, more efficient, and more expensive tunnels, I expect?

Mr. ATWOOD. Yes. I don't know what the requirements for additional tunnels are except in the hypersonic fields where missile cones are tested and such things as that. They are more expensive.

The CHAIRMAN. Mr. Hammill, do you have any questions?

Mr. HAMMILL. I have no questions, Mr. Chairman.

The CHAIRMAN. Mr. Atwood, you are not going to rush off, are you?

Mr. ATWOOD. I would like to stay through the session if I might.

The CHAIRMAN. We would like to have you available while we hear the next witness. Perhaps we would ask you a question or two further.

The next witness is Mr. R. C. Sebold, vice president, engineering, Convair Division of General Dynamics Corp.

Mr. Sebold, you are accompanied by Mr. C. L. Blake, transport systems manager of Convair. He will handle your charts for you?

Mr. SEBOLD. That is right, Mr. Chairman.

STATEMENT OF R. C. SEBOLD, VICE PRESIDENT, ENGINEERING, CONVAIR DIVISION OF GENERAL DYNAMICS CORP.; ACCOMPANIED BY C. L. BLAKE, TRANSPORT SYSTEMS MANAGER, CONVAIR

The recent impact of commercial jet transports and their immediate public acceptance has led to speculation as to the feasibility of the next step—supersonic transports. Convair appreciates the interest of this committee and the opportunity provided for presenting our thoughts on this subject.

Although the aircraft industry has directed much study and work toward supersonic transports in recent years, there are many questions for which final answers are not yet available. Nevertheless, a large number of facts about supersonic transports are known and a larger number of general impressions have been gained. Convair may provide some perspective on this subject as a result of our long, hard, practical experience in developing the B–58 supersonic bomber. Since the B–58 is the only airplane flying which is comparable to a supersonic transport, a modification of an advanced B–58 offers the simplest, earliest, and cheapest avenue for providing the operating and

supersonic cruise experience which is so vital to the successful prosecution of such a program.

In outlining to you the primary characteristics of any supersonic transport, I will explain why this foundation of practical operating experience is necessary for U.S. achievement of a satisfactory supersonic transport within a reasonable time.

Speed is the major attraction offered by air travel. Present technology assures that the next advance in transport speed, to the supersonic transport, will provide the greatest speed increase in transport history. In fact, we expect that speed will be advanced, in one step, more than during the entire time from the Wright brothers to the present subsonic jets. It therefore appears that supersonic speed should offer a strong stimulus to public air travel.

We would question public acceptance and the practicability of supersonic transports if it appeared that costs will be too high. Economic studies show, however, that if airline route structure will permit approximately the same equipment utilization as today, the cost to the passenger should not increase.

Studies, tests and evaluations also conclude that a supersonic transport can be built within the present state of the aeronautical art. Although extensive engineering development work will be required, no new basic knowledge is required. We know the job can be done, in general how it should be accomplished, but not yet all the details of the project.

The appeal of the supersonic transport will be somewhat diminished if passenger comfort or convenience are compromised appreciably. We feel that engineering design work can prevent the need for compromises of this type.

With all these attributes, the supersonic transport could fail if it presents serious problems in airline operation, utilization or in public annoyance. Although design studies and experimental tests should provide adequate solutions, the final assurance of their adequacy cannot be determined without extensive experience in flight operations.

Much attention has been directed toward the more obvious characteristics of the supersonic transport; such things as performance, operating cost, configuration development and passenger environment. Operational characteristics have also received some attention, and the NASA is planning a flight program to gain further knowledge. However, there needs to be a greater appreciation of the extensive experience which must be accumulated before a supersonic transport can finally be judged satisfactory. Perhaps more important, planning should be directed toward the exact methods and avenues required to acquire this operational experience.

As one would expect, introduction of a supersonic transport into scheduled airline operation will intensify a number of problems with which we are currently grappling. Air traffic control, airline scheduling, maintenance, and communications are a few of these. In addition, there are some problems peculiar to supersonic airplanes.

The characteristics of supersonic booms have already received a considerable amount of public attention. It is sufficient to say that we must fly at subsonic speeds below altitudes of about 35,000 to 40,000 feet, and I might add in here at this point to give some idea of what supersonic boom can do at low altitudes, it was suggested seriously by

Dr. von Carmin a while back that maybe we ought to take two or three airplanes and coordinate their booms and use the booms instead of bombs.

To minimize noise at the ground, we would like to fly as high as possible during supersonic cruise.

Although there are good theories available to predict supersonic boom intensity, while flight measurements generally correlate well with predictions, atmospheric conditions sometimes play tricks on us. At times the booms are greater than they should be. More work should and will be done in this area.

Another unique aspect of the supersonic transport will be its cruising altitude. It will fly between 60,000 and 80,000 feet, or twice as high as the subsonic jets. But human blood will not absorb pure oxygen above an altitude of about 40,000 feet. In case of a pressurization failure, the airplane could not descend to 40,000 feet in time to save those aboard, and the cabin pressurization system therefore must be for practical purposes 100 percent reliable.

This also goes for the fuselage structure as well as anything else, and I think this can be accomplished. We have in some of our studies looked to cabins without windows. So far the airlines have taken a dim view of leaving windows out of airplanes, but it is a safety item.

The CHAIRMAN. You have no windows in the evacuation planes, and in many military aircraft.

Mr. SEBOLD. That is right, and I think probably at these altitudes the sunlight will be so bright people won't want to look out anyway. We will have to furnish some other kind of entertainment, I guess.

We have had extensive experience in designing airplanes to operate at temperatures to 65° below zero Fahrenheit and down. This is a standard. We have actually had temperatures below 100° F. Except for experimental applications, however, aeronautical experience at elevated temperatures is comparativly meager. The supersonic transport will be encased in a film of air which grows hotter as the speed is increased.

At mach 2 this temperature is about 200° F. Above about mach 2.5, the temperature is so high that aluminum structure is no longer practical. At mach 3 the temperature rises to some 500° F., the highest setting on the average kitchen oven. We are therefore faced with the problem of either cooling quantities of equipment and structural components, or we must design and qualify a long list of items such as pumps, valves, tires, hydraulic fluid, lubricants, and so forth over a new range of temperatures.

Again we firmly believe that there are engineering solutions for each of these problems but experience will be needed to prove them completely adequate.

It is important that we recognize a particular problem which is created by the very nature of the supersonic transport. The development costs, unit price, and per hour operating costs of this airplane will be considerably higher than those for the subsonic jets, and when I say per hour operating costs, I mean airplane operating costs per hour. Passengers can be charged standard fares only because the supersonic transport should produce correspondingly more seat-miles per hour.

A mach 3.2 transport should consequently replace approximately 4 subsonic jets or 12 piston-engined transports. And this full potentiality must be actually realized in airline service if supersonic operation is to be profitable. The airlines will find some difficulty in maintaining this utilization, since passengers don't like to travel at inconvenient hours just to preserve favorable airline utilization rates. There have already been some examples of this on the subsonic jets.

With regard to reliability—I notice Mr. Atwood mentioned this and I couldn't stress this too much—it seems apparent that the reliability of this airplane must go beyond our present achievements if it is to be both a safe passenger carrier and profitable to the airline. We expect that systematic and scientific methods now being developed will show the way to attain these reliability levels. Opportunities for conclusive evaluation of the results, however, do not appear so promising.

In the past the reliability of transport aircraft has been developed by extensive experience with military airplanes of similar types. Our jet transport program would have been entirely different, and might not yet exist, if we had not had the experience of the B–47, the B–52 and the KC–135. These programs provided a wealth of engineering design information and, in addition, thousands upon thousands of service flight hours. As a result of this flight experience, significant changes were made in each of these designs, while the jet transports were designed in accord with the revised knowledge which was produced.

In comparison with this experience, the outlook for the supersonic transport is discouraging. Not only has manned bomber procurement been severely curtailed, but the present nature and timing of the program are unfavorable to a supersonic transport.

Just what are the prospects for getting service flight experience such as ushered in the subsonic jets? We have flying the B–58A, a multiengined, supersonic bomber, and have accumulated over 3 years of flight experience to date. As has been mentioned, the NASA plans to use the B–58A for simulating transport characteristics, gaining some experience in ground operations, takeoff and climb, sonic booms, air traffic control, cruise management, descents to landing, and landing. This information will be useful.

But it is significant to note that the B–58A was designed for cruising subsonically as well as supersonically. It uses engine afterburners for its penetration dash into the target, and its duration at that speed is less than for an airplane designed for all supersonic cruise without afterburners.

These limitations can be appreciated when it is considered that the entire B–58A program of these three squadrons cannot hope to accumulate 10,000 hours of experience at mach 2 and above soon enough to materially assist a supersonic transport program.

When and if the B–70 is developed as a military bomber, it would provide the experience in the mach 3 area. However, the B–70 program, as planned or even accelerated, will not provide the information required for a considerable period of time.

I do believe that there can be a logical program progressing from the present B–58A to an interim supersonic transport. The B–58C has been proposed to the Air Force as a possible growth version of the

B–58A. It has the capability of all-supersonic cruise up to mach 2.4 by using four large, non-afterburning J–58 engines in place of the present smaller, afterburning J–79's. I have mentioned afterburning engines, or non-afterburning engines twice. I think the importance of this is that non-afterburning engines use about half the amount of fuel as afterburning engines. This airplane is readily adaptable to an interim supersonic transport and its aluminum construction will be considerably cheaper, simpler to fabricate and easier to maintain than titanium or stainless steel required at higher speeds.

Its block speeds are the right order of magnitude to give good experience with supersonic airplane utilization, and a small number of these aircraft logging 2,000 or more hours of supersonic flight per year could build up the required experience quickly. These aircraft could be used for various military and special missions while gaining a great deal of prestige for the United States.

This interim supersonic transport would have a gross weight of about 200,000 pounds, which is less than any of the existing long- or medium-range jets. With 52 passengers, cruising at mach 2 to 2.4 at or above 60,000 feet, it would be capable of nonstop transcontinental ranges with reserves, as well as transoceanic flights with one stop. Its use of non-afterburning engines would make it suitable for operation from commercial airports, and I certainly subscribe to the remarks that Mr. Atwood made with respect to what has to be done in takeoff and landing of jets from airports.

The interim supersonic transport would probably differ considerably from the eventual, all-commercial supersonic transport, but it would be a practical airplane in terms of both performance and operating costs. I would judge the operating cost would be up to 20 to 25 percent more than the more optimumly designed mach 3 transport. In comparison, we expect the later, all-commercial airplane would have a gross weight of 360,000 pounds, cruise at mach 3.2 with 130 passengers, and have a range of 3,500 nautical miles.

In conclusion, Convair finds the supersonic transport both technically feasible and economically attractive from an operational point of view. We expect that foreign designers have reached the same conclusion. The manufacturer's point of view is somewhat different. We have managed to finance development of the subsonic jets, and we are one of the people who have done this in the 880 and the 600, but I do not believe that American industry can approach the supersonic transport on the same basis. The number of supersonic transports required for worldwide traffic will be small and the prospects for amortizing the investment does not therefore seem practical. In fact, we might expect that the major competition will not be between American companies, but between the United States and foreign countries, where the use of Government subsidies has already been indicated. In contrast, the limitation of U.S. funds is likely to strangle the acknowledged U.S. technical capability.

While it is believed that practical engineering solutions will be developed for all supersonic transport requirements, the prospects for service testing and extensive flight experience are bleak. The supersonic transport is promised no experience counterpart such as provided for the subsonic jets by the B–47, B–52, and KC–135.

A transport adaptation of the B–58C offers the simplest, earliest, cheapest, and perhaps the only practical avenue for providing this necessary flight and service experience. This airplane would also provide the United States its most direct method for achieving the prestige value of an early supersonic transport.

After this transport has accumulated the required supersonic flight experience, it could serve the U.S. carriers as an interim supersonic transport on high-density routes. It would thereby provide protection against the advent of premature foreign competition before a U.S. all-commercial transport can be produced.

The CHAIRMAN. Thank you very much.

Mr. SEBOLD. That is the end of my statement but I have a few charts over here to support some of the things I talked about and if you would like to see them I will be happy to show them to you.

The CHAIRMAN. We would be pleased to hear you explain them to us rather briefly because we have a few questions to ask you, and we must adjourn at noon; time is running short.

Mr. SEBOLD. On this chart (fig. 16) we show the effect of speed on blocktime versus range. In other words, the vertical scale is blocktime in hours and the horizontal is range in nautical miles.

The big jump in blocktime saving is between the subsonic jets and mach 2. There is still a reasonable and appreciable gain to be made beyond this up to mach 3 and it is worthwhile but there is a tremendous jump between subsonic jets and mach 2.

That is the real point of this chart.

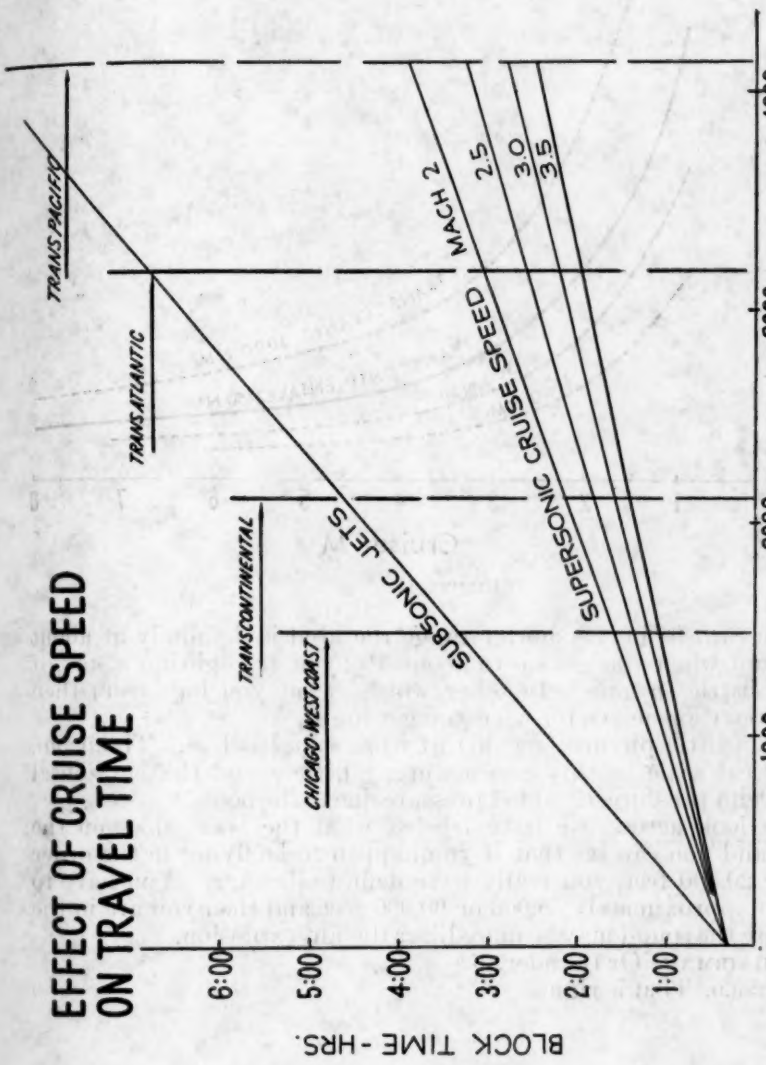
EFFECT OF CRUISE SPEED
ON TRAVEL TIME
BLOCK TIME - HRS.
6:00
5:00
4:00
3:00
2:00
1:00
1000
2000
3000
4000
RANGE - N.MI.
TRANS PACIFIC
TRANS ATLANTIC
TRANSCONTINENTAL
CHICAGO-WEST COAST
SUBSONIC JETS
SUPERSONIC CRUISE SPEED
MACH 2
2.5
3.0
3.5

FIGURE 16

We have the trip time (fig. 17) on the vertical and cruise mach number rather than range on the bottom scale. We show from 1,000 miles range to 3,000 miles range.

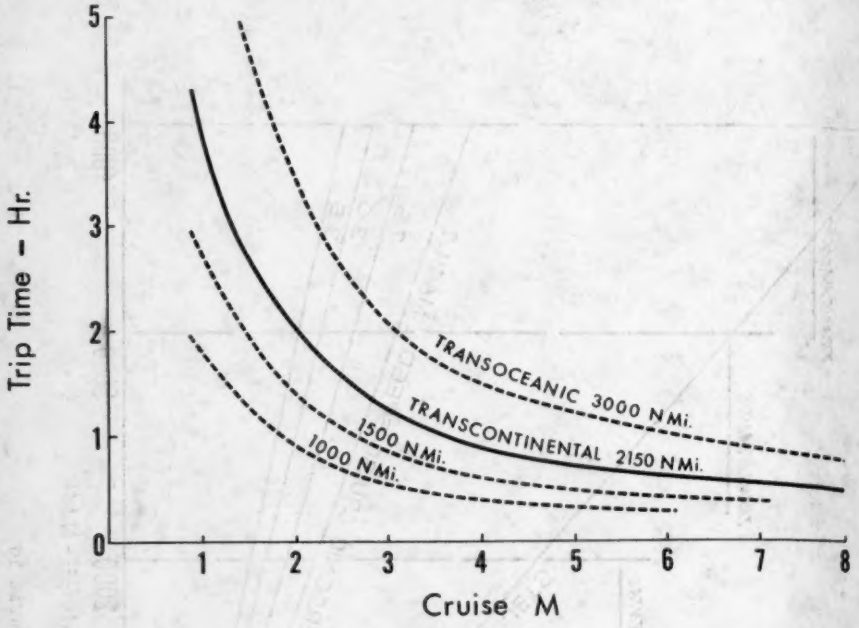

FIGURE 17

As you can see in the shorter range the need is definitely at about mach 2 and when you get up to about 3½, you are fighting a sort of a losing battle to gain. In other words, what you buy from then on gets pretty expensive for what you get for it.

This is a little picture (fig. 18) of what sound is like. The boom. The vertical scale in this case again is altitude and the horizontal scale is Delta pressure, or added pressure due to the boom.

If you look across, we have labeled what the boom does on the ground, and you can see that if you happen to be flying in the order of under 20,000 feet, you really have definite damage. You have to get up to approximately 55,000 or 60,000 feet and then you are in the area where the sound may be more like a distant explosion.

The CHAIRMAN. Or thunder.

Mr. SEBOLD. That is right.

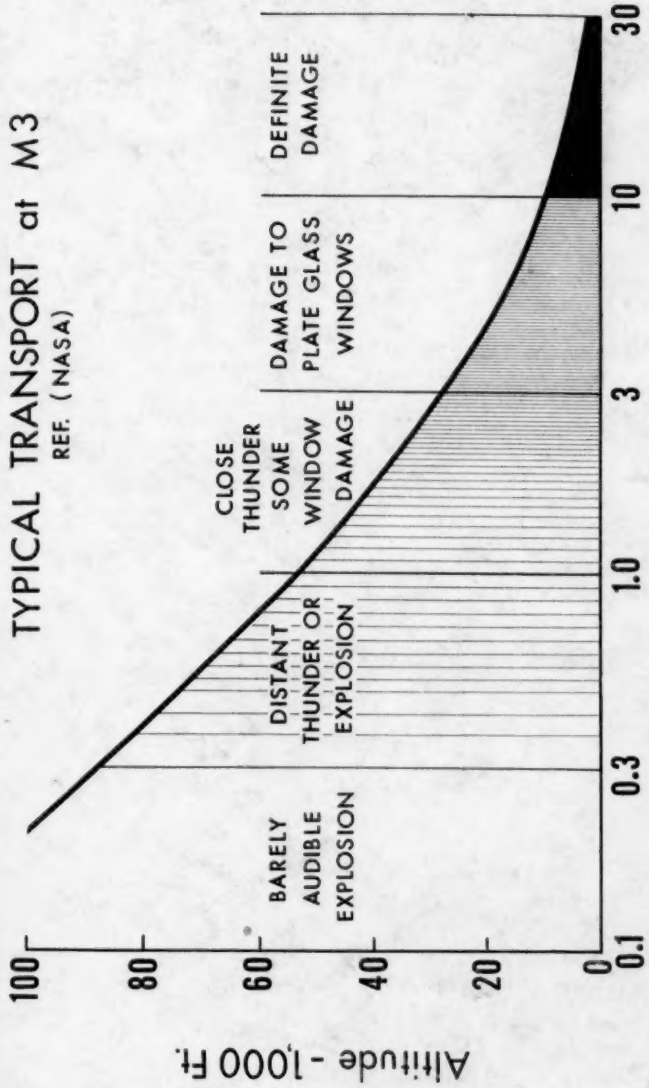

FIGURE 18

57537—60——9

I mentioned the B–58 supersonic adaptation. The B–58C (fig. 19) differs from the B–58A in that it has the J–58 non-afterburning engines on it. What we propose to do here would be to use the same engines and wing as the B–58C and the same tail and we put a new fuselage on it.

FIGURE 19

In this case (fig. 20) we have shown, 52 passengers sitting two abreast. Along the length of the airplane you can modify it for two, three, or four abreast. This is where the gross weight of about 190,000 pounds has 52 passengers.

FP-7178A
9 MAY 60

CONFIGURATION 58-9

GROSS WT.	190,000 LBS.	PASSENGERS	52
FUEL WT.	94,915 LBS.	BAGGAGE	40 LBS/PASS.
WING AREA	1780 SQ. FT.	CARGO VOLUME	3250 CU.FT.

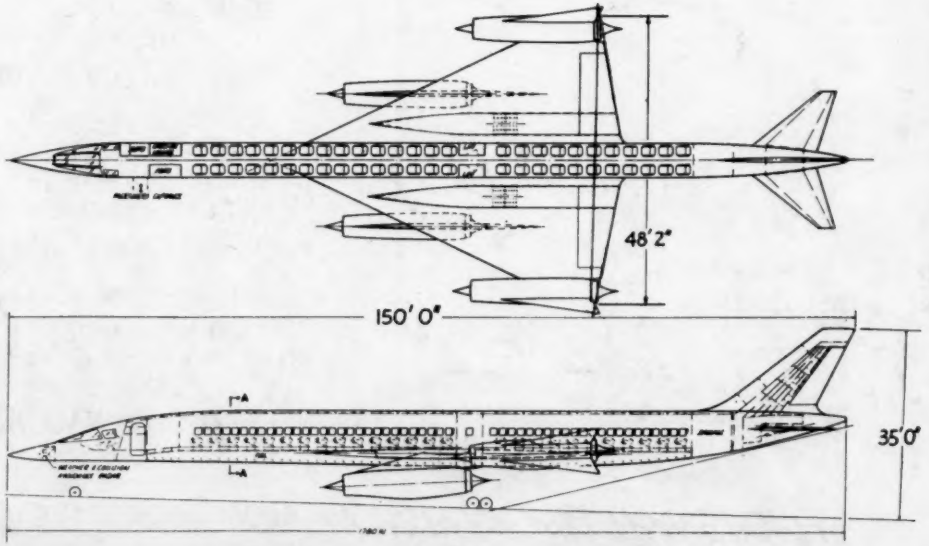

FIGURE 20

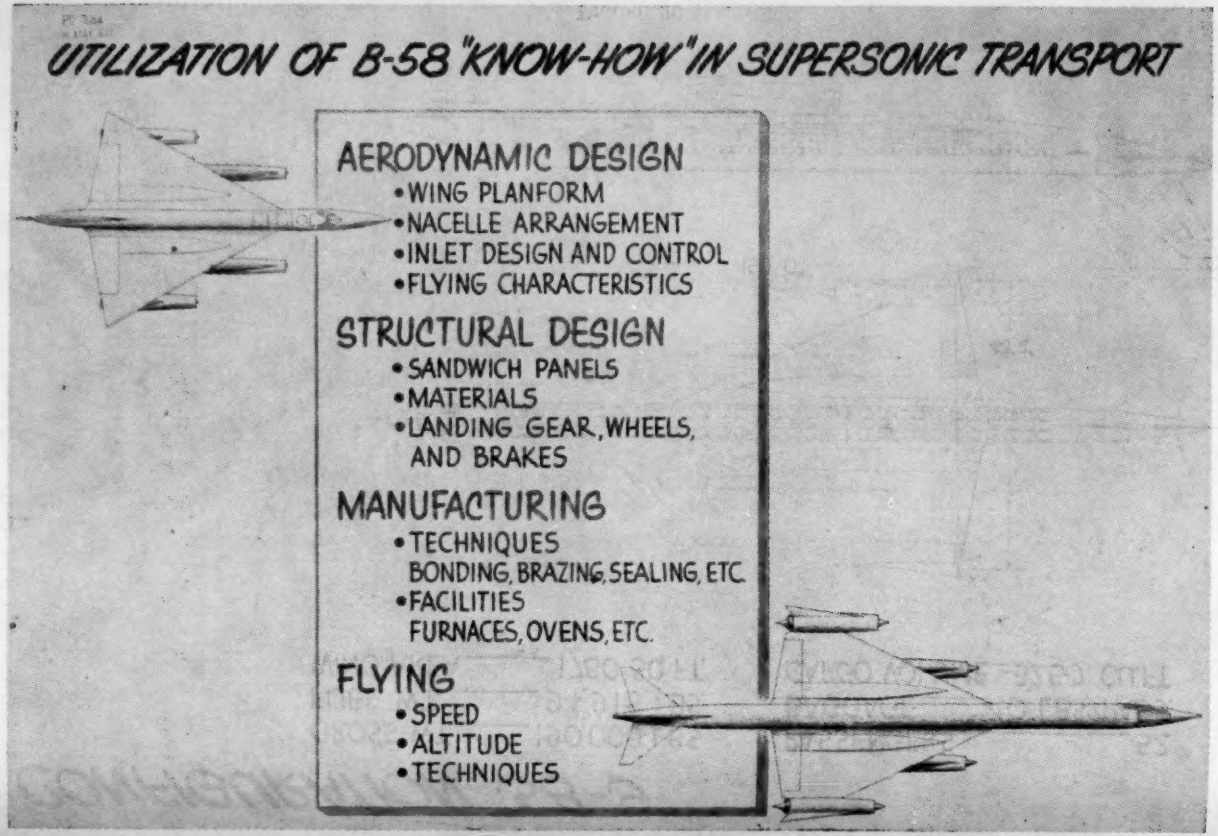
UTILIZATION OF B-58 "KNOW-HOW" IN SUPERSONIC TRANSPORT
AERODYNAMIC DESIGN
•WING PLANFORM
•NACELLE ARRANGEMENT
•INLET DESIGN AND CONTROL
•FLYING CHARACTERISTICS
STRUCTURAL DESIGN
•SANDWICH PANELS
•MATERIALS
•LANDING GEAR, WHEELS, AND BRAKES
MANUFACTURING
•TECHNIQUES
BONDING, BRAZING, SEALING, ETC.
•FACILITIES
FURNACES, OVENS, ETC.
FLYING
•SPEED
•ALTITUDE
•TECHNIQUES

FIGURE 21

This (fig. 21) shows what we get from the B–58C.

I wanted to show the size as compared to the current airplane.

This happens to be one of the versions (fig. 22) that we have studied on mach 3 transport and we show that overlaid on one of our model 600's to show you that while maybe they are getting a little heavier and faster, they aren't going to be a lot bigger. They are going to be a little denser.

FIGURE 21

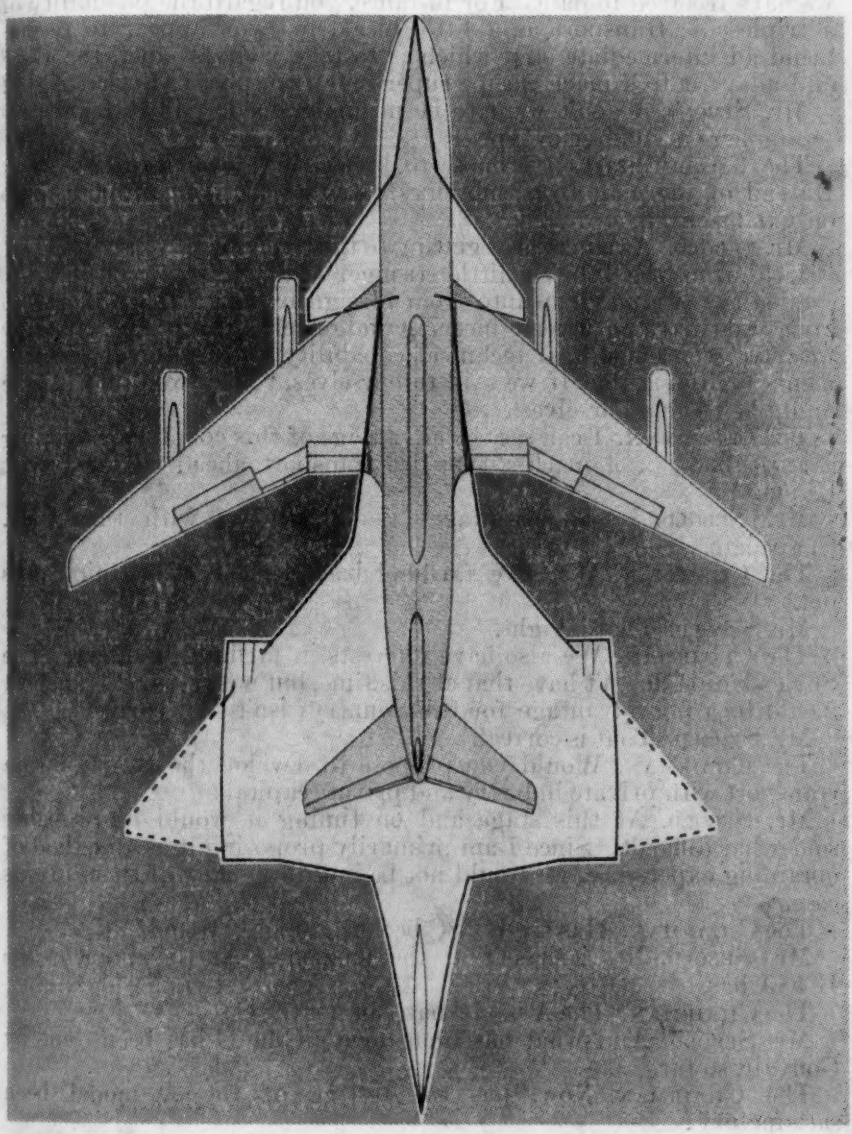

FIGURE 22

The CHAIRMAN. Your wing is pushed to the rear and broadened.

Mr. SEBOLD. It is pushed to the rear and instead of a tail in the rear we have a front tail, a lifting tail in this case.

The CHAIRMAN. The tail is in the front.

Mr. SEBOLD. The tail is in the front. Horizontally, that is.

That concludes the presentation and the charts, Mr. Chairman.

The CHAIRMAN. We thank you, Mr. Sebold.

Now, your statement is considerably different from other statements we have received to date. For instance, you regard the possibility of a triplesonic transport as a little bleak, but you appear to recommend an intermediate step which is to take your product, the B–58 and adapt it to a mach 2 type supersonic transport? Is that right?

Mr. SEBOLD. I don't want to be misunderstood. What I am proposing here is an interim type.

The CHAIRMAN. You propose to break this down into two steps. Instead of jumping from subsonic to triplesonic, you propose to go only to mach 2?

Mr. SEBOLD. As a means of getting to the triplesonic.

I think maybe I feel a little stronger than Mr. Atwood on what competition we may run into from foreign nations. It is difficult to say. You have to use engineering judgment I think and certainly we have seen enough of technical capability and technical developments in Russia that if we said to ourselves, "They won't do it," we might be fooling ourselves.

The CHAIRMAN. I can see the advantage of this country developing a triplesonic, or a mach 2-type jet transport ahead of the Soviet Union.

Mr. SEBOLD. I see advantages if we get on with them, Mr. Chairman.

The CHAIRMAN. We have farflung bases; the Soviet Union does not.

Mr. SEBOLD. That is right.

The CHAIRMAN. We also have interests in farflung industry. The Soviet Union doesn't have that at this time, but a large, fast transport would be a big advantage for this country; isn't that correct?

Mr. SEBOLD. That is correct.

The CHAIRMAN. Would you propose to develop the B–58C into a transport with private industry and private capital?

Mr. SEBOLD. At this stage and on timing it would be probably somewhat difficult. Since I am primarily proposing it as a method of obtaining experience, we would not be building many of them in this case.

The CHAIRMAN. Has the B–58C been thoroughly tested?

Mr. SEBOLD. No, it hasn't at the moment. At the moment the B–58A has.

The CHAIRMAN. The A model has, but not the C?

Mr. SEBOLD. And what has been done on the C has been done by Convair, so far.

The CHAIRMAN. Now, has the testing of the A model been satisfactory?

Mr. SEBOLD. Pretty much so; yes, sir.

The CHAIRMAN. How much more time will you need to test the C model?

Mr. SEBOLD. I would say, if you look at timing—and certainly I can get a lot of arguments on timing but if we look at timing I think you could probably start flying with experience on conversion of the B–58C, in a period of 4 to 5 years. If you went for a mach 3 transport I think you are talking much closer to 1970.

The CHAIRMAN. Ten years.

Now, suppose you converted a B–58C into a transport, how much would that cost? Have you any estimate?

Mr. SEBOLD. If we converted a B–58C we are probably talking in the order of less than a hundred million dollars.

The CHAIRMAN. And private industry could finance that, couldn't they?

Mr. SEBOLD. They could provided they can get over the financing of the current subsonic jets and I can assure you we are not over that yet.

Mr. MOELLER. Will the chairman yield?

The CHAIRMAN. Yes.

Mr. MOELLER. Mr. Sebold, what in your opinion would be some of the practical difficulties if our country were to attempt to join with, let us say, France and Great Britain in a project of this kind? In my thinking, there seems little reason for the United States alone to be the first to do this. If we want to be first, we certainly want to beat the Soviets at it, but in view of the fact that this is going to take millions of dollars and American industry possibly isn't ready to spend it and perhaps the Government shouldn't go into it too heavily, either, what would be wrong with joining with France and England? Certainly there aren't going to be too many of these planes when they are manufactured.

Mr. SEBOLD. I agree. Some of our studies have shown that maybe 150 to 200 airplanes might be required for the world market.

There is a rather difficult question to answer in the sense that you must know how you are going to go about it, you must have a plan, and certainly I agree with what Mr. Atwood said. You have to have somebody who is leading the thing, who is calling the signals. You certainly can't do this if you have a committee set up that is going to run it. It has to be somebody that you can pin the tail on.

I think we have to know a little bit more about some of the technology in the supersonic area of some of these countries. We have heard what some of the British have said and they seem to have quite an argument going at what speed they should design an airplane. In fact, I did see one chart presented where, on the basis of past history projected on the same straight line they came up with the number of 1.3. I don't think they will go ahead with such a transport because I think this is wrong and I think they will discover this. I don't think I can answer your question entirely satisfactorily at this stage, Mr. Moeller.

The CHAIRMAN. In designing that plane do you plan to be able to bring it into the big international airports without special adaptation of the airport?

Mr. SEBOLD. You should bring this in on the current airports from which the present subsonic jets are operating. I propose this as a way to get experience. I am sure there are certain aspects of approach speed and so on, knowing what the airlines want and knowing what

they should have, that would be somewhat high on this airplane. But this would not prevent it from accumulating the kind of flight and knowing how to use it, turn it around, what kind of maintenance is required, how much automatic checkout, what kind of maybe inflight checkout using computers and whatnot should be done.

The CHAIRMAN. We have heard testimony to the effect that if other countries produce the first operational supersonic transport, U.S. carriers would be forced to buy their fleets from that other country. American carriers would not be able to wait for an American product. Do you agree on that?

Mr. SEBOLD. Yes, I do. I think unless we had one that was pretty close.

We have a little experience in this—some experience, in the subsonic jets where the British came out with the Comet first. Now, actually, if they had not had considerable trouble with the Comet and it had been a really successful airplane from the start, it might have been a little different with the subsonic jets in this country. This is obvious speculation on my part but you can prove this at airports. People take the fastest airplane.

The CHAIRMAN. Well, you might have had the jet aircraft industry moving to England, had the Comet come out without any bugs; is that right?

Mr. SEBOLD. That is right.

The CHAIRMAN. Likewise the nation that produces the mach 2 or the mach 3 plane first, as a transport, is going to stimulate its long-range aircraft manufacturing industry; is that right?

Mr. SEBOLD. That is right; that is right. Our airlines, if they were operating subsonic jets against a supersonic transport across the ocean, would be in a pretty bad competitive position.

The CHAIRMAN. Now, Mr. Moeller has a very valuable suggestion about interesting other countries in this program. The difficulty, however, would be that it would of necessity be a Government enterprise. Some of us have been trying to keep this on a private enterprise basis, letting private industry design and develop the plane. What are the relative advantages of that?

Mr. SEBOLD. Well, I have my doubts that in this country the total supersonic development—and that includes, if we have an interim mach 2 and a final mach 3—I have my doubts whether private industry will be able to finance this completely. And if they don't it is my feeling that maybe the Department of Defense should be the agency which handles the development of the program.

The CHAIRMAN. Suppose we develop this mach 2 plane. That is, a commercial version of a B–58C, suppose we do that by 1965. Will the airline companies by that time have worked out their financial problems with the subsonic jet and be able to go into the supersonic jet?

Mr. SEBOLD. Well, all I can say is I hope so. I don't know the answer to that.

The CHAIRMAN. Well, they are having their problems now with the subsonic jets in financing them.

Mr. SEBOLD. That is right. Our company has sold no subsonic jets to anyone but airlines.

The CHAIRMAN. It would be foolish for us to undertake the commercial jet at mach 2 or 3 if it is not going to be bought and used.

Now, if it is a military development then, of course, that would fall in the Defense Department and would not fall in the category of being a development by commercial aviation. That is right, isn't it?

Mr. SEBOLD. Yes.

Mr. MOELLER. Mr. Chairman?

The CHAIRMAN. Mr. Moeller?

Mr. MOELLER. You mentioned certain difficulties with sonic booms, et cetera.

What about the damages that might be caused by the shock waves with respect to other air traffic, say flying at an altitude of 25,000 or 30,000 feet? Wouldn't they also be in danger to some extent and if so what can be done?

Mr. SEBOLD. Certainly this is an area in which we need experience. Two airplanes flying at supersonic speeds and passing each other very closely will have effect on each other. An indefinite effect. There certainly will have to be routes and patterns worked out. Of course, this will not be quite as severe at higher altitudes but at the present time I would not expect an airplane to be flying either mach 2 or mach 3 at 35,000 feet. I would expect that it had been climbing subsonically to about this point and then start accelerating to its cruising speed and reach its cruising speed somewhere in the area of its cruising altitude which should be at least 60,000 feet or better. But you are certainly right. I don't want to be in either airplane that passes very close.

The CHAIRMAN. Would your radar be able to pick that up?

Mr. SEBOLD. Oh, yes, they would be able to pick up the other airplane. But I think this is a matter of traffic control.

Mr. MOELLER. Can you work this out scientifically in advance and know just how close they can be without feeling the effects one upon the other?

Mr. SEBOLD. I don't know the answer to that at the present time. This is certainly one area in which we need experience. I can name probably a lot of them.

The CHAIRMAN. I would like to ask you about what you said about sonic booms and comparing them with bombs. Are you serious about it? What can be the effect of a shock wave?

Mr. SEBOLD. Well, if we look at some of the damage that has taken place by inadvertent sonic booms of airplanes flying over various areas, I think it sort of has somewhat the same effect that some of the bombs had on Germany in the last war. It knocks out windows, can damage flat structures. It is just a plain concussion.

The CHAIRMAN. A plane of this speed would not produce a shock wave sufficiently severe to take lives, would it?

Mr. SEBOLD. I don't know. I don't think I can answer that.

The CHAIRMAN. In other words, there are lots of areas that need to be explored?

Mr. MOELLER. Will they take windows out?

Mr. SEBOLD. I think the point here is that we are not going to be flying at those speeds at low altitudes.

The CHAIRMAN. Your approach is very interesting, sir, and we appreciate your willingness to come here and give this committee some of the results of your experience, especially in the handling of a B–58 which your company has developed.

Now, I am going to ask counsel to approach the Air Force with reference to a further witness regarding the development of the B–70, and also to make arrangements with Mr. Hibbard of Lockheed to appear. With the hearing of those two witnesses these hearings will be concluded.

I want to thank you, Mr. Sebold and Mr. Atwood, for giving us very fine statements.

The committee will recess until further notice.

(Whereupon, at 12 noon, the subcommittee recessed to reconvene at the call of the chairman.)

SUPERSONIC AIR TRANSPORTS

TUESDAY, MAY 24, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SPECIAL INVESTIGATING SUBCOMMITTEE,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. The subcommittee will come to order.

This morning we are happy to have two very important witnesses. One of them is the Chief of Staff of the U.S. Air Force, Gen. Thomas D. White.

General White is making an outstanding record as Chief of Staff of the Air Force during a very troublesome period in our national history. I think we are very fortunate to have a man like him in the important position of Chief of Staff of the Air Force.

Without further ado this morning, I want to welcome you, General, on behalf of the committee. You have a prepared statement and we will be very happy to have you proceed with the statement. I understand you have to get away promptly, so we will ask some questions and arrange for you to get away in ample time to fill your other engagements.

STATEMENT OF GEN. THOMAS D. WHITE, CHIEF OF STAFF; ACCOMPANIED BY COL. ANDREW S. LOW, CHIEF, OFFENSIVE SYSTEMS GROUP, OFFICE, DIRECTOR, RESEARCH AND DEVELOPMENT, U.S. AIR FORCE

General WHITE. Thank you, Mr. Chairman. I was very happy to comply with your call to appear before your committee again.

The subject of our discussion this morning is supersonic air transportation.

The CHAIRMAN. If I may interrupt you for a moment, General, as you know we have been holding hearings on the feasibility of supersonic jet transports. Everything seems to dovetail, to link up with the development of the B–70. So it seemed to the committee that we couldn't properly complete this subject without getting a full report as to the importance of the B–70, the status of the B–70 development, and the prognosis for the future development of the B–70.

With this in mind, we asked you to come here and bring the committee up to date on what I consider a very, very important subject. Today will be the last day that we will have hearings on this particular subject. It is vital to sum up what has already been said.

General WHITE. I will try to do that, sir.

Supersonic air transportation is naturally a matter of great interest to the Air Force and I welcome this opportunity to discuss this important matter with you today.

I understand that previous witnesses at these hearings have, in the course of their discussions concerning supersonic flight, focused attention on the military aspects of such advanced performance. This, of course, is quite logical. To achieve longer ranges, higher altitudes and greater speeds is a constant Air Force goal and, at the same time, a vital requirement to assure that we maintain aerospace supremacy.

This aerospace power of any nation is comprised of many elements, but the primary forces which influence and further the development of a nation's aerospace power are science, industry and civil and military aviation interests. Each one of these forces enters the aviation development cycle at a different point—but all of them must eventually form the first team of aerospace power.

The speed at which this cycle moves depends not only upon the rate of technological advance in the science of aviation, but also upon the pressures of the moment.

Development of jet aircraft, for instance, was expedited by military necessity—first by the requirement to win a war, and then by the continuing necessity to keep strong military aerospace power in the face of a constantly growing threat. For this reason, military aviation, in conjunction with science and industry, has been the pioneer force behind the growth of jet aerospace power.

Our Nation's total aerospace power is the direct result of a team effort. This is never more clearly demonstrated than when an attempt is made to break out specific contributions by science, industry and civil and military aviation to the development of an individual aircraft.

Experience cannot be measured in dollars and cents—nor can any clear-cut attribution of the invaluable lessons derived from millions of flying hours be pinpointed in an aircraft development program. The attainment of a specific aircraft performance capability is an evolutionary process, and the knowledge and experience in all fields must be used. For example, there is no question that valuable data derived from the design, development, production and operation of the B–29 contributed heavily toward the successful development of the Boeing Stratocruiser.

In the same way, the experience in subsonic jet operations gained from the B–47 and B–52 programs undoubtedly had considerable influence on the design and operation of aircraft such as the DC–8 and the Boeing 707.

More than ever, the development of aircraft with today's high performance capabilities depends upon the pool of knowledge, resources and experience which each one of these elements of our aerospace power can contribute.

In recent years our national efforts to improve this country's aerospace capabilities have become increasingly complicated by two factors. The first of these is fast moving and increasingly complex technology.

Secondly, and closely associated with the first, are the greatly increased costs involved. Rapid technical advances in propulsion,

materials, electronics and communications have made possible performance capabilities considered beyond reach only a few years ago. And with these advances have come costs so high that the financing of such radical new equipment cannot be accomplished without direct or indirect assistance from the Government.

As one example, the design, engineering and production problems have become almost as unbelievably complex as the equipment itself. The B–17 of World War II, for instance, required approximately 200,000 engineering man-hours to bring it to the point of first production flight. The B–58, the first of the supersonic bombers, required over 9 million man-hours. A little quick arithmetic shows that this is an increase in effort over the B–17 by a factor of 45. The increased effort is reflected, of course, in much greater performance—a result of refined engineering and production techniques.

Speed is but one element of performance, but it is a good example of our rapid progress. You will recall that aircraft in World War II were unable to penetrate the so-called sonic barrier. It was not until October 1947, that an Air Force pilot in an experimental aircraft finally exceeded the speed of sound.

Mach 2—twice the speed of sound—was first exceeded by one of our experimental aircraft in December 1953 and today several of our latest combat fighter aircraft and the B–58 bomber are attaining such speeds regularly. In fact, our combat aircraft are now approaching the limits of the material used in their construction.

As you know, aluminum is generally used for aircraft surfaces. At speeds between two and three times the speed of sound, the surface heating of the aluminum skin of an aircraft becomes so great that sustained flight results in structural deterioration. Thus, to fly at higher speeds, we must substitute a more heat resistant material such as steel.

Providing we can develop engines with sufficient thrust, this will permit us to attain aircraft speeds up to approximately five times the speed of sound. To attain even faster speeds, we will have to introduce more effective heat resistant materials to take the place of steel. This phenomena has been described as the heat barrier, but as you can see it really is not a barrier at all. It is an ever-rising heat condition associated with increasing speeds within the atmosphere. I consider the solution to be the problem associated with this condition to be as important as the conquest of the sound barrier—both represent significant breakthroughs in the science of aeronautics leading to greater progress.

The question is sometimes asked whether such research is really necessary when we already have missiles which attain speeds of 16,000 miles per hour—and when we have various types of satellites under development which will have effective payloads in terms of warning equipment, communications, and so on. The answer is clear.

We must strive to conquer any so-called barriers to further progress in manned flight—not because it is a challenge, but primarily to develop the answer to the threat of exploitation of the same advancing technology—militarily or commercially—by others. Manned vehicles will be needed to fulfill the requirements for the total aerospace force structure this Nation needs for the future.

This is the reason that the Air Force is working on improved manned vehicles such as the X–15 and a prototype of the B–70 at the same time that we develop more sophisticated ballistic missiles and study the use of satellites in defensive operations. The B–70 development will, we hope, lead to a mach 3 bomber capable of achieving altitudes on the order of 70,000 feet and ranges exceeding those of our present B–52's. Work on the prototype airframe for such an aircraft is currently authorized and underway. Such an aircraft would ultimately "pay off" in several ways.

First, it would form an essential part of a carefully dovetailed blend of combat systems.

Secondly, since its capabilities would be superior to our current bomber force and different than those of our missile force, it would create new defensive problems for potential enemies.

Third, development of the B–70 could well lead to a multipurpose aircraft capable of defense and satellite launching operations as well as bomber sorties.

And lastly, a mach 3 aircraft will open the door to even higher speeds and performance by large manned vehicles—and the global transports of the future.

The B–70 represents the best manned, strategic weapon system that can be produced, within our current technical capabilities, for use in the time period when it is needed. It is not merely a drawing board dream, dependent upon the planning of events, or inventions, or scheduling of "breakthrough," for success.

Actually the idea for the B–70 was conceived 8 years ago. Studies were started in 1953 by the Air Force and the Boeing Airplane Co. and shortly thereafter by North American Aviation. Development contracts were let to these two companies in 1955. The following year it became apparent that the design then possible would not produce an aircraft with adequate performance. To get the desired range, the best that could be obtained was a monster aircraft that cruised at subsonic speed and could attain a supersonic speed of mach 2.4 for a short duration.

Development was reinstated in 1957 and has now progressed to a point where fabrication of components of an aircraft has begun. I think we can conclude from this that even as of today the contribution that this program can make to the achievement of a supersonic transport is not merely academic theory, but years of sound scientific productivity as well as a high degree of technical confidence. Each element of progress made in the B–70 development program is a step closer to the realization of the supersonic transport.

Five years ago even the most optimistic among us had to concede that a practical supersonic transport was still over the horizon. Now, as evidenced in testimony before this distinguished committee by authorities recognized as representatives of a cross-section of the aeronautical world, there appears to be a unanimity of agreement that it is possible—that is, provided military development leads the way.

In fact, even the statement that a mach 3 supersonic transport is technically and economically feasible, can be made today only because of the extensive studies, research, experimentation and laboratory testing that has gone into the B–70 development.

We as a nation, long have held the respect of the world for our leadership in the field of commercial aviation. I am utterly convinced that this leadership may well be lost if we do not continue to progress—and attain the capabilities which can be achieved by forging ahead in the area of supersonic air transportation.

I look upon the development of the B–70 as a national effort—one which can lead directly not only to the most advanced possible bombardment aircraft, but to a supersonic passenger or cargo carrying transport aircraft for our civil aviation as well.

Thank you, sir.

The CHAIRMAN. Thank you, General White. That is a fitting statement on behalf of the B–70.

The witnesses that we have had here in reference to the trisonic transport have indicated that 80 percent of the development of the B–70 could be usable in the development of the triplesonic jet transport. Would you say that figure is too high?

General WHITE. I think it is a conservative figure.

The CHAIRMAN. You think it might even be above 80 percent?

General WHITE. Yes, sir.

The CHAIRMAN. So that when the B–70 is developed, then the actual cost of the triplesonic jet transport will be some 20 percent of what it would be otherwise if you did not proceed with the B–70?

General WHITE. I believe the figure is somewhat in that ball park, yes, sir.

The CHAIRMAN. What is the present status of the B–70?

General WHITE. The B–70 is now a prototype program. We have one airframe under construction and we have authority to go ahead with a second prototype. This means an airplane that will be able to fly, but it will not have the various equipments and systems, subsystems we call them, that go into the airframe to make it useful as either a weapon system or as a transport.

It is the basic airframe, engine, landing gear, and minimum facilities for communication for safety of flight in the testing program.

The CHAIRMAN. Try as we have during the course of these hearings to seek an alternative, everything has tied the triplesonic transport to the B–70. There seems to be no escape from that.

General WHITE. There is no other development program underway in that field.

The CHAIRMAN. When do you expect to have your prototype in shape to fly?

General WHITE. The first prototype is scheduled to fly in December of 1962 under the present program.

The CHAIRMAN. You have all the money you need for that?

General WHITE. We have all the money we need for the first prototype. We have some difficulty with the second one because of lack of funds in the time period that would enable us to go directly on the best schedule from the first prototype to the second prototype. We will either have to slip the date of the first one or we will have a hiatus between the first and second if we move at the best possible speed to get the earliest flight.

The CHAIRMAN. If those who are interested in the development of the triplesonic transport have access to the data which you develop in building your prototype for the B–70, these agencies that are inter-

ested, for instance, NASA and the FAA; do they have access to the data?

General WHITE. I am sure they do. Whether there are patents involved, I am unable to say. Perhaps Colonel Low can answer that question better than I.

Colonel LOW. The information is being bought by the Government. So it is Government information, yes, sir. There are proprietary rights.

The CHAIRMAN. There would be no reason that NASA in developing the triplesonic transport——

Colonel LOW. I see no reason———

The CHAIRMAN. There is no reason why they couldn't have the information?

Colonel LOW. We would be glad to do it for them.

The CHAIRMAN. The B–70 flying at a 70,000-foot altitude, would you say it would be above normal hazard of being brought down by shellfire?

General WHITE. I wouldn't say that 70,000 feet is in an area which air defense weapons won't go. But I would say that at the speeds this airplane will travel, with the defensive devices, electronic countermeasures, tactics, and so on that would be in a weapon system, there is no question in my mind this aircraft will survive and penetrate to make it a worthwhile weapons system.

I think recent events show the ease with which an aircraft can penetrate an air defense system.

The CHAIRMAN. By the same token, a high-flying triplesonic transport would have the same degree of safety in transportation, isn't that right?

General WHITE. You mean as a——

The CHAIRMAN. Fast and high in its flight.

General WHITE. You said as transportation, Mr. Chairman. You mean as a weapon or——

The CHAIRMAN. I don't mean as a weapons system, but as a transport for moving troops and supplies and things of that sort, and commercially too.

General WHITE. In respect to the other aspects, I don't think that the altitude has a bearing other than it is the optimum altitude to get the performance of the engines and the aerodynamic design of the airplane.

The CHAIRMAN. It is the altitude that will give you the maximum performance in flight.

General WHITE. Somewhere in that neighborhood.

The CHAIRMAN. In the opinion of some people the B–70 was cut simply for economy reasons? Do you agree to that?

General WHITE. I can't agree to that, much as I am in favor of going on with the B–70 at a higher rate. I do not honestly consider that it was a decision made on a budgetary basis.

The CHAIRMAN. $75 million has been allowed for the prototype program of the B–70. Is that sufficient money?

General WHITE. It is sufficient to produce the first prototype, together with the funds in prior years.

The CHAIRMAN. I don't think it is part of the purpose of this committee to go into the cost of your weapon systems because this com-

mittee is interested in scientific development rather than in the armed services and in weapons system. However, I would like to ask you what are the disadvantages of relying entirely upon a missile system for our deterrent capabilities?

General WHITE. There are a good many, sir. I think that I will simply talk about several major reasons.

One is inherent in the missile systems, namely, that with a missile there is no recall capability. If we should be attacked, the warning time at best, even under the BMEWS and possibly later on with satellite warning, is going to be in minutes. The decision to respond with a counterattack must be made within those few minutes. If missiles compose our entire offensive force, somebody has to push the button that releases the missiles. Once they are released, there is no recall. It is going to be an extremely difficult decision in the age of satellites. Further, I am sure there are going to be many false alarms. There will be mechanical difficulties with our warning systems, just as there are with every other kind of mechanical device. We will suddenly have a blackout in some or all of our warning systems. We won't know whether they have been hit by an enemy or whether it was a power failure, or fuse blown or what. It could have been an attack. Is anyone going to plunge this world into war on the basis of that kind of information?

I think the odds are very unlikely. Time being so important, we need another method of response. That method is through the manned bomber which can be recalled and which is presently established under what we call the positive control system whereby the commander of SAC can release his force on his own initiative at any time that he feels the situation requires. This means that the bombers can go to a certain point but they must come back if they don't get other positive information to continue on course.

The net result is to give time to the decision-making process to determine whether the reason that caused the commander of SAC to launch his forces is a valid one or not. This time will range from a minimum of 2 hours to somewhat more because that would be the distance out to which these bombers would fly before they would have to come back.

Without a bomber force we would be simply dependent on a static system which is completely mechanical and once launched cannot be recalled.

I think that is the major reason that we must have a mixed force.

The CHAIRMAN. What you mean is that the manned bomber is susceptible to a preliminary decision that can be reversed, but a rocket isn't; the decision is final with a rocket and missile.

General WHITE. That is exactly right, sir.

This is another point. Missile systems to be effective would have to be manned and ready 24 hours a day. Thus, if there is a period of tension, if there is a cold war aspect in which we wanted to let the world know that we were serious about something, that we were worrying, that we propose to increase our readiness, with a missile system there is no way in the world for anybody to know that anything is being done because those units will be at the maximum alert constantly. On the other hand, with aircraft, you will recall crews because they will be on varying stages of alert. You can redeploy

them. Your readiness degree will become apparent very quickly. You might redeploy tankers, for example, whereas with the missile system it is static, unseen, always ready, so it is completely static. Ther are no degrees of alert and nonalert with an effective missile system.

The CHAIRMAN. Let me go back to the transport. In the development of the transport, you will have a very fast, high-flying plane that will be able to deliver troops or supplies to any portion of the world. Do you believe that has a military value?

General WHITE. I think it has a very high military value, Mr. Chairman. I believe that general war is the most dangerous threat to this country, but I also believe that we must be prepared to engage as necessary in local or limited wars. There is no question in my mind that prompt and decisive action is the key to that sort of situation. The B–70 or a transport that could carry, as the B–70 would be able to do, on the order of six of the Army's Honest John missiles and their crews to anyplace in the world in about 5 hours might have a very decisive effect.

I have discussed this with the Chief of Staff of the Army, General Lemnitzer, and he expressed, when I last talked to him, a very great and positive interest in having that kind of quick response with Army forces.

The CHAIRMAN. So that any expense in connection with the development of this aircraft for a commercial purpose would be useful for military purposes?

General WHITE. Well, I am sure that the basic airframe could be used for the very purpose I was talking about, troop airlift. I think there would have to be greater modifications, a greater element of development for commercial use, which would stem directly from the basic airframe that we have underway today.

The CHAIRMAN. One more question and then I am going to recognize some of the other members of the committee.

You have indicated that you have had tribulations in the development of the B–70. Would you explain what the Air Force is now doing to meet the problems that you have encountered in reference to the B–70?

General WHITE. I will put it in general terms and then ask Colonel Low to answer in more detail.

The Air Force is doing everything that it can within the amounts of money allocated to us to get on with this first prototype and for that matter, the second prototype, just as fast as possible.

Colonel LOW. I think as General White has said, we have had our ups and downs in the program. We are trying to go as fast forward with the resources that are given to us as can be done.

The CHAIRMAN. Are you on the ups now or downs?

Colonel LOW. We are meeting the goals with the type of airplane we are building.

General WHITE. I think I should make clear the ups and downs are not a question of technical feasibility. They are a question of funds only. I don't say that this is a problem that is very simply solved. There are practical solutions to each element and each component of the aircraft.

The CHAIRMAN. Money problems are never easily solved.

General WHITE. I think I can make clear to you without having to go into a classified session, one of the things:

For instance, in order to get within the funds allocated we are using a landing gear on these two prototypes which would not be the landing gear of a weapons system, for the simple reason that we find that we can have a usable landing gear—and it is astounding what the cost of a landing gear on any airplane is—by using certain substitute materials to permit flying the prototype. But if we went into a weapon system we would have a different landing gear. It is that kind of improvisation in a few areas which you might call the ups and downs of it. Some of them are technically more difficult than that one.

The CHAIRMAN. Mr. Martin.

Mr. MARTIN. I yield to Mr. Riehlman.

Mr. RIEHLMAN. General, may I say that I commend you on the very fine statement you have made here this morning and your statement in respect to this mixed force concept. I am in accord with your views 100 percent. It seems to me that this is the strongest endorsement that could possibly be given for moving as expeditiously as possible in the construction of the B–70.

Of course, as you have properly said, if we are going to be the leader in commercial aviation in the world, the construction and the development of the B–70 is going to be the route that we will have to follow to get into that position. Am I correct in that?

General WHITE. That, in my opinion, is true, sir. I would not say there could not be parallel lines to develop a mach 3 commercial transport, but to start all over again would cost an enormous amount of money. So this to me is the practical, economical way to go, both for the commercial version and for a military version.

Mr. RIEHLMAN. You were saying that this is just a prototype development, and there is no additional equipment of sub-systems that would be necessary to carry out this program. What additional cost would it be to the Government to have sufficient equipment to assure us that this is going to be the type of bomber that we really want and an effective weapons system?

General WHITE. To develop the fire control systems, the navigational systems and so on that would go in this airplane as a bomber on a purely prototype basis would probably be too expensive to do as a risk program. But if we know we are going to go into a weapons system which is what I feel should be done, we do know what it would cost to reinstate the original program now. However, we have already lost roughly 15 months, I think it is, in getting back to a weapons system program.

The requirement would be $285 million to bring us back to the full scale program that we had.

Mr. RIEHLMAN. Do you have that scheduled in the next fiscal year?

General WHITE. No, sir. Naturally, as long as I am called upon by congressional committees to state my opinion, I am going to state it frankly. I intend, unless something very unusual occurs in the weapon systems development field, to state my case for reinstating it as a weapons system next year, as I have done this year when I have been questioned in proper circles.

Mr. RIEHLMAN. I appreciate that very frank answer.

The reason I ask it is to tie in with the interest that this committee has in our supersonic transport program. I think every person that

has been before the committee expects that the military is going to lead this program, and that we are going to derive the technical information and assistance that we need from the military's program to build the supersonic transport for commercial purposes. They are both dovetailed in together. Unless we move with the B–70, we are not going to get the information unless we want to duplicate the effort and spend additional millions of dollars for that purpose.

General WHITE. And lose a great deal of time in the process.

Mr. KING. General White, just one line of questioning.

The magazines and periodicals of popular consumption more or less analyzed the situation as follows: They said that 4 or 5 years ago, whenever it was the Russians invited General Twining over to see this great spectacular display of manned Russian bombers, they did it to more or less mislead him—sand in his eyes, so to speak. They wanted to give America the impression that they were launching this great program of manned bombers, but as a matter of fact that was exactly the time that they had decided to more or less scrap their manned bomber program and go into intercontinental ballistic missiles on a big scale. What they were trying to do was mislead us and they are putting all their emphasis on ICBM's. That is the word that is going around.

I would like to get your comment as to whether you feel the Russians' emphasis on intercontinental ballistic missiles has been to such an extent that they have for all practical purposes scrapped their manned bomber program, or do you think that their manned bombers will constitute a serious threat in addition to their ICBM's for some time to come?

General WHITE. There is no question, Mr. King, that the Russian Air Force has a very large inventory of manned bombers today and that they are continuing some production. In addition to that, I believe they are developing new types of bombers in spite of what has been said.

I think it is fair to say that with the advent of the ICBM it behooves us also, as we are doing, to have ICBM's in our inventory.

I anticipate that the proportion of missiles to bombers will increase as time goes on, up to a certain point.

For reasons I gave earlier, I feel there must always be a certain force of manned weapons. I may be sticking my neck out a little bit, but I read a great deal about the end of the manned bomber and the uselessness of the bomber. I would only say that there has always been, since before the days of Billy Mitchell, even a connotation of something nasty about the bomber. The bomber is the thing that is saving our neck today insofar as military deterrence is concerned, has done so ever since World War II, and it certainly played the major part, in my opinion, in many areas in World War II. I don't think the bomber is dead. It has created new problems in military thinking. There are many circles that would be very happy to just think away the bomber and they have thought that for many years without success. I am convinced that the bomber is here to stay. It is our backbone today just as it is probably the Russian's backbone today.

Mr. KING. I appreciate your answer. I know you didn't come here today to discuss the Bomarc and maybe you would rather not even mention it, but I do have a special interest in it.

Would you say that assuming that the Bomarc meets satisfactory tests, and I understand just within the last week it has had one or two spectacularly successful tests, assuming that it does meet those tests, you would feel then that the Bomarc defense system would develop, it should retain a place in our defense arsenal for at least the foreseeable future?

General WHITE. Very definitely, sir.

We need the Bomarc to meet the threat of the immediate future—the intermediate future, I had better say. I also foresee the day will come when in my opinion, no weapon system that we have in our service today will be an adequate defense against the manned aircraft. This development will come about through the advent of long-range air-launched missiles, such as the Sky Bolt, which we have under development. The Sky Bolt will be launched from an aircraft while the aircraft is still some 1,000 miles from the target. Unless you either have a completely new concept of disposition of fighters, and probably fighters of a different type from anything we have today, nothing that we have today can meet such a threat. For example, the Bomarc has a maximum range of about 400 miles; that means that it is useful against a launching platform that comes within 400 miles of the Bomarc's location. But when the launching platform is 1,000 miles away, there isn't anything on hand or on the drawing boards that is going to meet that threat.

However, the Sky Bolt is some time off and we think we are ahead of any other nation in that particular kind of development. For the very long term, timewise, neither the Bomarc nor any manned fighter system that we have today is going to give us a defense against the long-range air-launched missile.

Mr. KING. If the Soviets have the counterpart to our B–70, the Bomarc would not be effective against it; is that correct?

General WHITE. No, sir. I feel that the Bomarc and some of our fighters will be effective, to a degree, against an airplane such as the B–70. But it is going to be very tight—the effectiveness of our, or anybody else's, defenses is going to be much degraded by the advent of a very high speed mach 3 bomber than can fly at the altitudes that such an airplane will fly. You add an air-launched missile to the situation and you have a serious problem in air defense.

Mr. KING. Do we have reason to believe that the Soviets are working on that which could be considered the counterpart to our B–70?

General WHITE. I must be mindful of the fact that this is an open session. I will only state that the Soviets are very aware of the value of high-speed weapons and I think we can be sure they are working in that field.

Mr. KING. Thank you. That is all, Mr. Chairman.

The CHAIRMAN. Mr. Van Pelt.

Mr. VAN PELT. General, what is anticipated with the X–15?

General WHITE. The X–15 is purely an experimental vehicle. Its main purpose is to conquer, shall we say, that last frontier that lies between the palpable atmosphere and true outer space. It is largely a matter of a steppingstone from the normal winged aircraft to a more advanced manned system such as the Dynasoar, which will actually go further out into space than any of our present systems.

Mr. VAN PELT. Thank you.

The CHAIRMAN. It is a sort of satellite that orbits the Earth, and yet it approaches an aircraft in the ability to move out into outer space and then return, is that correct?

General WHITE. The X–15 does two things, primarily. It is giving us data concerning very high speeds. The X–15 should go 3,600 miles an hour, which is considerably more than mach 3 but considerably less than orbital speeds. Orbital speeds will come with the boosted vehicles. The X–15 is also giving us information on materials, controls, propulsion, and more importantly perhaps, it is providing information on the environment in which man must live to operate the machine.

The CHAIRMAN. I have been a little disappointed in the progress that is being made to use that X–15 in outer space. What would you say about the progress that has been made?

General WHITE. I think the progress is reasonably satisfactory, Mr. Chairman. The X–15 is a new approach and we have only three of these aircraft. We are handling the program in a very scientific and calculated manner so as not to start running before we walk. We are in the trotting stage right now.

The CHAIRMAN. You have had no crackups?

General WHITE. We had one accident which did not destroy the vehicle. It was repaired. The accident only set us back a couple of weeks because No. 2 vehicle was right behind it. I think we are more or less on schedule as of now.

The CHAIRMAN. You are satisfied with the progress made?

General WHITE. I always like to go faster, but I think this is a proper experimental program the way it is going now.

The CHAIRMAN. Mr. Morris.

Mr. MORRIS. I notice that in talking about the B–70 versus the ICBM, you said one of the advantages of the B–70, a bomber of that nature, was that it could be recalled. The bomber is an offensive weapon as most lay people think of it. Wouldn't that also be true in a defensive weapon?

General WHITE. I don't believe I follow you, sir.

Mr. MORRIS. Wouldn't the same criteria hold for a defensive weapon?

General WHITE. Being able to be recalled?

Mr. MORRIS. Yes.

General WHITE. Yes, sir.

Mr. MORRIS. Such as a mach 3 fighter versus the missile?

General WHITE. That is true. However, the defensive weapon is not going to drop bombs or missiles on the enemy so you don't get into the same kind of problem. It automatically recalls, its range is short and it is only designed and really able to fight against an incoming enemy weapon.

Mr. MORRIS. As Mr. King mentioned, the Bomarc weapon system, I am sure that you realize, like all of us do, that the funds that we are able to provide are limited in all of these programs.

General WHITE. I am probably more aware of that than almost anybody.

Mr. MORRIS. It is always a matter of judgment as to which of these types of weapons systems or any type of programs that is chosen. I can't quite understand the Bomarc versus interceptors equipped with air-to-air missiles.

When you stated that even if the Bomarc B were fully operational today and had been successfully tested in supersonic targets, the maximum range of it is only a little over 400 miles. A supersonic manned bomber, equipped with some of the missiles that we have operational today, we do have missiles that are operational today, am I not correct?

General WHITE. Yes, sir, the Hound Dog is just coming in.

Mr. MORRIS. Air-to-ground missiles. If the Bomarc B were fully operational today wouldn't it be an effective weapon system against the B–52 equipped with our latest air-to-ground missile?

General WHITE. Yes, sir; it would be against the B–52 because of the relatively short range of the Hound Dog missile; not against the Sky-Bolt. However, the first Sky-Bolts are about 4 years away.

The answer I think to your question, sir, is that there isn't anything that we or anybody else has today, that I know of, which is going to be effective against an air-launched missile with a thousand-mile range.

Mr. MORRIS. It may not be completely effective, but it seems to me that in view of the money that we have to put into these programs, we should consider a manned interceptor equipped with a missile to be more effective and surer and have a higher kill capability than the Bomarc if it were operational.

You say that it has had some successful tests. But it has also had some very unsuccessful tests. We have spent about two and half billion dollars in it already.

General WHITE. Let's talk about the test programs first, if I may. There has been a lot of publicity about the failures of the Bomarc and practically nothing about its successes. I would be very happy, either individually or to the committee, to give a complete rundown on the Bomarc test program which on balance is highly successful.

We have given such a briefing to the House Appropriations Subcommittee and are scheduled to give it to the corresponding committee in the Senate this week.

The point is, sir, that I agree with you that judgments are required all along the line; how best to distribute the resources that we have; what things do we really feel are vital? There is no question in my mind that a certain level of defense against the enemy threat—against the continental United States or the continental North America—is a vital element of our military system.

Against the manned bomber threat or the air-breathing threat as we know it now, and for the intermediate future, there are only three types of weapon systems that can apply. I will divide them into two parts; what we call the area system and point defense. The area system includes the manned interceptor and the Bomarc which reach out to intercept the incoming weapon platform, be it manned bomber or an air-breathing missile. Point defense is the defense over the target area. The air-breathing threat is with us today and for some years to come. I don't put the long-range air-launched missile within the immediate future. I would say it will be some 4 years before we will have such a weapon and at least an equal length of time before the enemy might have it. So we must cover the U.S. continental defense in that time period. The weapons to do it with are manned interceptors or Bomarcs. We expect, and have asked to have a mix

of the two. The Bomarc is very useful within its field. However, when looking at the mix I spoke of as between the growing ICBM threat against us and shall we say the slightly rising or levelling off in the manned-bomber threat, I came to the conclusion that somebody had to step up to the problem and ask to appear before the Appropriations Committees, with the blessing of the Department of Defense, to recommend a further cutback in the U.S. continental defense against the air-breathing threat.

One of the key items was to reduce the Bomarc program to an area defense of the vital northeast part of the United States and to redeploy fighters to fill the gap in those areas which were originally programed to have Bomarcs.

Now, there isn't anything else you can do, unless you provide a lesser defense—which, in my opinion, has already occurred in a major way twice within a year. The only thing you can do is provide the Bomarcs or provide interceptors. The interceptor will not do everything that the Bomarc will do, partly because of the very high and low level capabilities that the Bomarc has, and because to substitute fighter interceptors for Bomarcs at this period would be more expensive. The Bomarc program is well down the line. The funds already obligated are high. We can finish the program as recommended—the curtailed program—for very much less than the minimum equivalent in fighter interceptors. The House Appropriations Subcommittee recommended substituting 50 F–106's for the Bomarc program. Well, a very minimum equivalent would be 200 F–106's and not 50. We are either faced with going on with the Bomarcs, getting more interceptors at at least three times the cost—not only in capital costs, but in M & O costs and with additional personnel costs—or having a gap. My answer is the program that I have introduced, sir.

The CHAIRMAN. Let's get back to the transport and the B–70.

Mr. MORRIS. General, in your opinion, the B–70 is not only necessary and vital as a weapons system, but it would make a great contribution to science and to the civilian population?

General WHITE. I am absolutely convinced of that. I can't say in sweeping terms that if we don't go on with the B–70—but if we don't go on with this kind of development, the science of aeronautics in which the United States has a worldwide lead is about dead. We will have stopped in our tracks when there is a great future ahead. The B–70 comes into the picture because we are already down the line somewhat on it. We have spent several hundred million on it. It is, in my opinion, technically the right direction to go. Everything points to national need, and I am speaking only now of the science of aeronautics, national prestige, even export someday. I understand the aeronautics export market is roughly No. 6 in the list of U.S. exports. We must stand first just as we have always. To say that the heat barrier has stopped us when we have a practical way to go, to my mind, is not just good sense for the Nation.

The CHAIRMAN. General, we were the last nation of any size and consequence to develop the jet commercial plane, weren't we?

General WHITE. I think the British developed the Comet before we had a comparable or better transport, but I am not a great expert on the race, shall we say, in civil aviation. It is my impression it was a very close race as to whether the 707 or the Comet was going

to make the first scheduled transatlantic flight. Perhaps Mr. Johnson, who follows me and who is on the civil side of it, will be a better witness in that respect. I don't think we were very far behind. Due to our production facilities, we quickly caught up and now our jet transports are the standard of almost every airline, not only in this country, but in the world.

The CHAIRMAN. How much more money will we need to complete the B–70 prototype program?

General WHITE. The B–70 prototype program requires, some 140 million in fiscal year 1962. We have sufficient funds to complete the first prototype in the present budget, with the exception of some $20 million which would cover the gap between the completion of the first prototype and the second one due to fiscal year fund availability, as I understand it.

There could be a hiatus; the answer to that is either to get the $20 million or to slip the flight date of the first prototype so we have a continuous line with the second prototype.

The CHAIRMAN. You need about $147 million more to complete your prototype?

General WHITE. To complete the second one.

The CHAIRMAN. Then after that, if the ship is airworthy, then you put it into production?

General WHITE. To go on to production costs considerably more money depending on the rate at which you produce the aircraft.

The CHAIRMAN. You pick up a transport from the experience of the B–70?

General WHITE. Yes.

The CHAIRMAN. At that high rate of speed and that altitude, would you say that either the B–70 or the transport would be immune to defenses as we have them now?

General WHITE. I don't anticipate that there is much of a threat against transports today, or even in wartime, in the normal course of events. Their danger will be on the ground in time of war rather than in the air in the normal event.

The CHAIRMAN. Of course, it just depends. If you use a transport in time of war for carrying military supplies, it would be subject to attack.

General WHITE. It could be, but it will be far less vulnerable than any transport we have ever had in history.

The CHAIRMAN. What percentage would get through?

General WHITE. As a transport?

The CHAIRMAN. At an altitude and at that speed.

General WHITE. To the areas that we would move the transport—and this is only an indication of my feeling—I would say 99½ percent of them would get to where they were going.

The CHAIRMAN. You think if we develop this transport, and likewise a B–70, that we will have a ship that will get through 99½ percent of the time?

General WHITE. I don't think the bomber will; no, sir.

The CHAIRMAN. You think the transport——

General WHITE. The transports will not be going over enemy territory, but the bombers will be penetrating enemy territory and will

suffer attrition. Any attrition is bad, but I think it will be at an acceptable figure.

The CHAIRMAN. Because of its speed and altitude, might you send it over enemy territory?

General WHITE. You might.

The CHAIRMAN. I will not pursue that any further at this time. Let me ask you this:

Assuming the Soviets go ahead with a program to develop a transport and show up here with a mach 3 transport, and if we don't, what would be the reaction among our people? You are a military man. You have studied the reaction of our people.

General WHITE. I think that type of thing would have a very grave effect on our own people and perhaps even a greater one on our allies. It would show we had slipped in our ascendency in the technical race.

The CHAIRMAN. When I was in Turkey, the officials there were constantly asking me if the United States was going to keep up with the developments in the Soviet Union. It brought home to me, very definitely, the fact that other nations are watching our development.

General WHITE. I can scarcely visualize what consternation there would be among our own civil airlines and our own air travelers if the Russians, or any other nation, had a schedule from London to New York in 2½ hours and we were doing it in 6 hours, which is about what we do now, or a little more.

It would have a devastating effect.

The CHAIRMAN. We wouldn't be selling many transport planes.

General WHITE. Nor many airline seats after a while.

The CHAIRMAN. Any further questions? The General does have another commitment.

General, I think that covers the subject very well from our viewpoint. I think that the committee knows what you need in reference to the B–70 program. By the same token, it knows what is needed for the transport program. I think it is a very vital program. I hope our people see the need, as I do, for going ahead with it.

General WHITE. Thank you, sir. It is a pleasure to appear before your committee.

The CHAIRMAN. It is nice to have had you and your staff this morning. Thank you very much, General.

We now have Mr. Vernon A. Johnson, vice president, eastern region, Lockheed Aircraft Corp., who is pinch-hitting for the witness we had scheduled the other day, Mr. Hall Hibbard. Mr. Hibbard was taken sick and couldn't be here. We are happy to have you this morning, Mr. Johnson.

Mr. JOHNSON. Thank you very much, Mr. Brooks.

The CHAIRMAN. The committee wants to get the attitude of your company and yourself as to this problem.

Mr. JOHNSON. Thank you, sir. It is a pleasure to have an opportunity to appear before you to talk on this subject.

The Lockheed Co. has been interested in this matter for some years. I would like to go through my statement if I may.

The CHAIRMAN. Will you proceed, sir?

STATEMENT OF VERNON A. JOHNSON, VICE PRESIDENT, EASTERN REGION, LOCKHEED AIRCRAFT CORP.

Mr. JOHNSON. Within the past 25 years, the rapid evolution of air transport design has reduced the 2,500 miles between east and west coast from 16 hours to 12, then to 8, and now to a mere 5 hours for today's jet traveler.

While this continuing evolution in itself symbolizes an impressive achievement, we must not forget that today's jets are the end result of design concepts which were laid down a full 7 years ago. During this period, while present turbojet airliners were being built, tested and integrated into service, the state of the art of aerodynamics has continued to develop, and at an unprecedented rate.

For example, in the military field the United States already has several operational fighters, such as the F–104 and the F–106, and a large bomber, the B–58, all of which fly at twice the speed of sound. The B–70, now under development, will operate at even higher supersonic speeds. Consistent with these developments, we now have within our grasp the technical ability to produce even more spectacular commercial aircraft, such as the supersonic transport.

The American supersonic transport we at Lockheed envision is an all-steel aircraft capable of carrying more than 100 passengers at cruising speeds of more than 2,000 miles per hour, operating at 70,000 feet of altitude and over ranges of more than 4,000 statute miles.

This tremendous increase in speed from the subsonic range of five to six hundred miles per hour, to a velocity of mach 3—three times the speed of sound—will reduce the travel time between New York and Los Angeles to about 1¾ hours. A New York to Paris flight will take only 2½ hours.

The technical feasibility of such an aircraft already is well established—in fact, there no longer can be any doubt that it will appear—and soon. The only question is, how soon, and which nation will have it first?

Other nations are already at work:

In considering the 2,000 mile-an-hour transport, one of the first things which should be realized is the almost certain probability that such aircraft are now being developed in Great Britain, France, and in Soviet Russia.

Great Britain, which lost its early leadership in the subsonic jet transport field to the United States, has been working for at least 3 years on preliminary studies for a supersonic transport aimed at regaining her former prestige.

The British Ministry of Aviation recently awarded "preliminary study" contracts to the Hawker-Siddeley Group, to the English Electric-Vickers-Bristol Group, to Bristol-Siddeley Engines and to Rolls-Royce.

Because the companies mentioned already had financed an enormous amount of effort on supersonic transport studies, including the Bristol T–188 all-steel, flying test bed, industry sources believe that these Government contracts are retroactive in intent, representing compensation for work already completed. The same sources believe also that should the decision be made to go ahead with a full-scale flying proto-

type, Britain would regard this as a super-priority project, amounting almost to a "crash program," in order to break into the new supersonic transport market ahead of any competition, particularly from the United States.

In April of 1960, it was reported that two French manufacturers, Sud Aviation and the Marcel Dessault Co., has combined their efforts in the race to build the world's first supersonic airliner. This would be a mach 2 transport, designed for medium-range service. Both companies undoubtedly have the necessary capabilities, and their entrance into this field is a logical follow-up to the successful introduction of the present Sud Caravelle.

Even more significant, Soviet Russia, which has designers of proven ability, and also the necessary production and technical facilities, is certain to market a supersonic transport as soon as possible. This view recently was expressed by Gen. Thomas D. White, U.S. Air Force Chief of Staff, in statements to a congressional subcommittee. After discussing a new Soviet military aircraft, General White said:

> The U.S.S.R. is also working on a transport aircraft that could operate at supersonic speeds * * * Such an aircraft will greatly augment the capabilities of their air transport organization, Aeroflot, which can be quickly converted to an adjunct of the military air forces. The worldwide gain in prestige accruing to the Soviet Union from the early introduction of a supersonic transport—would be invaluable to a nation involved in the air power race.

Perhaps the importance of the supersonic transport to the economic position of Britain, France, or Russia can best be appreciated by analyzing our own need for such an aircraft. Let's consider that need now from four different standpoints: Our national commerce, our national industry, our national security and our national prestige.

First, our national commerce. During the last century the speed and dependability of our clipper ships led the way in helping establish the United States as a major power in world trade. Since that time our commercial transportation systems have been instruments of national policy, helping to mold our national image, both at home and overseas.

In recent years, America's development of superior aircraft has made this Nation preeminent in world air commerce, but we cannot afford to become complacent. Today we face a growing challenge to our position in the field.

A competitor who writes his own rules: Aeroflot, the Soviet airline, has the world's largest fleet of transports, including over 250 of various jet-powered types. It already operates over a route system twice as large as that of any free world airline, and even now it is negotiating for a network of new routes within the free world.

Our Federal Aviation Agency has described what we shall face in the years ahead:

> They will be meeting us head-on in every field of civil aviation. They will be scrambling for passengers, freight, and aircraft sales and rentals. And they will be trying to move out into every pocket of the globe, including our own United States. Economics—the necessity for a sound return on investment—will not hamper the Communist drive. If past performances are any indication, the Soviet civil air campaign will be one of prestige, propaganda, and never mind the cost.

American manufacturers today are encountering Soviet brand competition for commercial aircraft sales, particularly in the Orient and

the Middle East where Russia's pricing policy is based apparently on strategic aims rather than sound economics.

If we are to meet this competition successfully, we must continue to give our customers superior equipment, finer, faster aircraft with greater earning potential. An American-built supersonic transport is a logical answer.

From the standpoint of our national industry, the 2,000-mile-an-hour airliner would be one of the most rewarding forward steps ever taken. It could create as much as $2 billion worth of new business in the aircraft field, stimulate new job opportunities, develop additional work for a host of supporting industries, and it also would provide an effective counterthrust against the increasing competition from abroad.

Immediately after World War II, the United States was practically the sole producer of transport aircraft. Today Russia, East Germany, France, England, Canada, Japan, Holland, and Italy also are competing for the world turbine-powered transport market. This competition has become so vigorous that more than 135 foreign-built turbine-powered aircraft are already being operated, or have been ordered, by airlines here in the United States.

One result of this trend has been its detrimental effect on the balance of payments problem which now confronts the United States in its international trade and financial transactions. For the past 9 years, with one exception, our dollar payments abroad have exceeded our income from foreign sources.

During the last 2 years, the imbalance has become very severe, amounting to a $3.4 billion loss in 1958 and an approximate $3.7 billion loss last year. These losses include both gold and U.S. dollars. Although recent reports indicate some improvement in 1960, the cumulative deficit is still a serious matter.

If our Nation takes a decisive lead in developing and marketing the supersonic transport, it could help substantially toward restoring reasonable equilibrium in the balance of payments. Receipts from exports of "Made in U.S.A." aircraft would be measured in millions of dollars.

On the other hand, if we fail in these endeavors, the negative effect caused by foreign domination of this market could be critical. The U.S. airlines will need a far greater number of supersonic aircraft than will the foreign operators—excluding Russia. Not only would we be losing dollar income, we would suffer a tremendous outflow of dollars as the major American carriers scurried to buy abroad in order to preserve their competitive position on international routes.

If the United States is to take full advantage of these market opportunities, our development program must move forward with speed and energy. The more effective our market coverage, the lower will be the unit cost of the aircraft, including the prorated amortization of the development burden.

Contributions to national security: In order to obtain the greatest yield from the investment in basic development, and to satisfy, if possible, the pressing demands of national security, the military applications of the supersonic transport should also be examined.

Certain military missions could be accomplished by the mach 3 transport, using practically the same configuration as the basic com-

mercial version. For other more specialized missions, in which greater payloads or necessary heavy military equipment would have to be carried, it would be feasible to add structural reinforcements and systems modifications to satisfy those requirements. These adaptations could be made at a small fraction of the cost of starting over with a basic airframe designed for each specialized use.

With these provisions in mind, the mach 3 airplane definitely could fulfill a military multimission concept. Studies indicate that this aircraft could accomplish at least these five military missions:

1. Supersonic tanker;
2. Recoverable booster for launching missiles;
3. Reconnaissance;
4. MATS cargo and troop-carrying mission;
5. High priority personnel transport for the special air mission fleet.

Historically the prestige of U.S. aircraft has been one of our strongest international assets.

Now, there is every reason to believe that Russia is already at work on a supersonic transport. It would be well to remind ourselves that in the development of subsonic airliners, Russia's TU–104 was operational in passenger service long before our own 707's and DC–8's. If the Soviet Union should be first again with the far more advanced mach 3 transport, the severity of this new blow to American prestige would be obvious.

Suppose we should ignore this challenge and adopt a "wait and see" attitude; or suppose we decide that the effort to compete is simply too costly and let Russia be first by default. Without belaboring the threat of world domination, or exaggerating the Soviet's avowed present intentions, let's consider the possible consequences of such a decision.

With a supersonic airliner, Russia's Aeroflot would be able to offer service two to three times faster, and could overwhelm any competition from free world airlines.

U.S. commercial air carriers would be forced to choose between accepting a subordinate role in the world system, or buying foreign equipment in order to compete.

America would sacrifice the indispensable gains in technology and productive capacity which would have accrued from its own supersonic transport program. This would put our industries at a critical disadvantage, not only in the export and domestic commercial markets, but from the standpoint of national defense as well.

The loss of valued export customers would result either in further dissipation of our gold reserves, or in restrictive controls which would damage trade relations with friendly nations.

The Western Allies' confidence in U.S. leadership would be shaken, and the loss of prestige would generally weaken our influence in world affairs.

At first glance these may seem to be dire predictions, but recent history demonstrates how seemingly minor causes can have magnified effects through the tightly interwoven world economic structure. If such a chain reaction should develop, Soviet Russia would have made big gains in her campaign for world domination through economic penetration.

Mr. C. R. Smith, president of American Airlines, said on May 2 of this year;

> The United States is the world leader in aviation. It may be of great importance, in the kind of world in which we live, to be sure that we maintain that position. Whether we can continue to be the leader, if we are not willing to lead in the introduction of supersonic air transportation, remains to be decided.

The United States has the ability of producing a supersonic airliner, fully developed and operational, ahead of all foreign competition, if we take the initiative now and give the program adequate priority. To many people such an achievement would be even more impressive than a sputnik or a Discoverer. The average man has never seen a satellite, but a supersonic airliner would be within the realm of his immediate, personal experience. He could see it—even ride in it, for just the price of a ticket.

With all these important factors in its favor, why isn't Lockheed, or one of the other major U.S. manufacturers already building a supersonic transport?

Certain preliminary work has been done. Lockheed. for example, already has invested more than $2.5 million in advance study, analysis, wind tunnel and laboratory testing. Although technical discussion is outside the scope of this presentation, we can assure you that the major problems of design, development and production have been realistically assessed, and we know that they can be solved with our present knowledge of the art.

Our advanced research in the missile field has contributed important data on the aerodynamic configuration; we know that the aircraft can be built with existing materials, powered by existing engines, and can operate from existing airports. Other problems, such as cabin environment, community sound levels and outside skin temperatures, have been studied and are capable of solution. Moreover, economic studies show that seat-mile operating costs will be comparable to those of present subsonic jets, indicating an excellent return on investment.

To repeat then, with all these important factors in its favor, why isn't one of the major U.S. manufacturers building a supersonic transport?

The answer is simply money.

The individual American aircraft manufacturers do not have the financial resources to carry out such a program, in addition to meeting heavy existing commitments, without help.

The transition from production of present subsonic jets to the supersonic airliner of tomorrow will require a continuing program of research and development before the flying article can be completed. Because of this aircraft's unique speed and altitude environment, it will have to be equipped with new and even more sophisticated systems of control, communication, navigation and instrumentation, all of which will require research, expert design and exhausive testing.

The necessary changeover from aluminum to steel and titanium as the principal structural material to meet mach 3 requirements alone will necessitate a large investment in new equipment. It will mean the development of more advanced fabrication techniques. New tooling must be designed and built; engineering, planning and vendor

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development must be worked out; and a prototype must be constructed and flight-tested, all adding to the total development investment.

Industry estimates for the entire project, through commercial-type certification, range between $250 million and $500 million, depending on the size and detail design specifications of the airplane.

In estimating the potential market for a mach 3 airliner, it should be realized that, although the cost per aircraft will be much greater because of its more sophisticated design, the number of aircraft required will be fewer. The reason for this is that the much higher speed of the supersonic transport will enable it to do the work of three present-day subsonic jets, or 10 of the now obsolescent, piston-engined types.

Further, studies indicate that only the larger airlines with the longer, well-traveled routes can profitably employ the supersonic transport. Thus, it is anticipated that the market may be limited to some 6 U.S.-flag airlines and 12 foreign carriers as immediate customer prospects.

In our present circumstances, private industry simply cannot finance an effort of this magnitude. The intense competition for present subsonic transport business has divided the world market into such small segments that none of the U.S. manufacturers has yet recovered his development investment in these aircraft. It may be several years before this financial burden is lifted, if ever.

In the past, airline orders and associatel pre-payments have helped to underwrite development costs. This avenue is now closed because our customers also will be financially preoccupied with amortizing present equipment investments during the 5 to 7 years needed for the supersonic transport development. It is logical to believe, however, that they will want to take advantage of the new aircraft's greater earning potential. There is also some indication that purchase financing can be arranged when the supersonic transport is ready to enter service.

To finance a program as large as the supersonic transport development, a manufacturer normally turns to the major banking institutions for long-term loans. Large-scale funding can be arranged for new commercial ventures when ample market opportunities exist for the product, and when the borrower is in a favorable competitive position.

In this situation, however, the total free world market is extremely limited, and the borrower would not be competing solely against other private companies adhering to the same economic rules. His principal competitor would be one or more powerful foreign nations whose pricing policy on the product would need be regulated only by diplomatic expediency, rather than sound business principles—whose resources are measured on a national scale, rather than on an industry scale, or an individual corporate scale.

It would be unreasonable to expect any American manufacturer to enter such a competition unaided, and it would be totally unrealistic from a banker's standpoint to back such a venture.

In Lockheed's opinion, the logical course of action is that Congress provide the funds necessary for this program. This course of action is entirely proper when vital objectives, clearly involving the public welfare, cannot be achieved with private resources.

There are a number of precedents for such a solution. For example, the shipbuilding industry receives substantial funding by the Govern-

ment which is represented in our fleet of privately operated, flag-carrying vessels. Recently the world's first nuclear-powered merchant ship, the NS *Savannah*, was developed as a Government project through cooperation between the Maritime Administration and the Atomic Energy Commission.

As other examples, there are stationary nuclear power reactors which have also been sponsored by the Atomic Energy Commission and the X–15, and other research aircraft, which are being handled by the National Aeronautics and Space Administration.

Surely the supersonic transport, with its far-reaching significance to industry, commerce, national prestige, security, and international relations, qualifies for the necessary governmental financial support. This would not necessarily represent an outright expenditure. We believe it would be reasonable to prorate all or part of the development cost over a production forecast of, say, 150 aircraft and to reimburse the Government as each aircraft is sold. If the probability of military orders could be taken into account, the development burden per aircraft unit would be reduced to a more moderate figure.

This is a subject which the Congress must study carefully, and the committee is to be complimented for its searching inquiry in which no constructive approach is being ignored. The first question, of course, is this: Should we or should we not go ahead? We at Lockheed believe that the Nation's self-interest requires an affirmative answer.

To summarize, it would be unwise to risk further delay.

The necessary steps to implement a development program should be taken immediately in order to have a supersonic transport in service on the earliest possible date.

Events are shaping so rapidly that our defense posture and the entire balance of world trade and national prestige could be altered within the next 5 to 7 years, and this period could well represent a turning point in our history. The seriousness of the problem demands that we mobilize fresh thinking and devise new approaches that will lead to action. We should remind ourselves of the severe handicap we assumed by our late start in missiles and rocketry.

Over a year ago Lockheed went on record with the statement that a supersonic airliner could be operational as early as 1965 if implemented at that time. Since then, precious months have slipped by; our Nation must make better use of the ones ahead.

Naturally, we at Lockheed would be proud to build America's first supersonic transport, but we feel sincerely that the important thing is not so much which member of our industry family does the job, but that the job be done. We are ready to contribute our energy and capabilities to any role, in any combination of effort that will bring this new concept of air supremacy into reality.

The CHAIRMAN. Thank you, Mr. Johnson, for a very fine statement. I think your company ought to be complimented for sending you to deliver that statement this morning.

First, I take it from your statement you feel that the jet transport should be a national program.

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. Therefore it should be undertaken by the Nation.

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. That private industry do the research and development of the transport and actually build the prototype.

Mr. JOHNSON. Yes, sir; that would be a logical series of steps.

The CHAIRMAN. I assume that Lockheed would be proud to have that position. But you also show a generous attitude in that you accept the possibility that you may not be the principal in the research and development and construction of the prototype. Have you thought out a method whereby industry in the United States might be brought together solidly behind a program to which the Government may make some contribution?

Mr. JOHNSON. There has been a great deal of discussion of this, Mr. Chairman. No firm ideas have been reached, I guess. I think it might be interesting to point out that in the program devised for the B–70, although the prime contract was given to one company, the North American Co., that in the beginning of that program when it was expected that a production program would go forward currently, three or four of the other large aircraft manufacturers were brought in as major subcontractors to contribute their abilities and also their personnel and their know-how to the entire program. This is the kind of thing which possibly could be accomplished in the case of a commercial airplane as well.

The CHAIRMAN. Since the Air Force is building the prototype, the B–70, would it be proper in a national program for the Air Force to build this transport?

Mr. JOHNSON. The Air Force is not building it, sir.

The CHAIRMAN. I mean they let the contract.

Mr. JOHNSON. The Air Force has let the contract for it to be built, but the prototype is being built by the North American Co.

The CHAIRMAN. Correct. The Air Force operates through the individual companies. That is what I had in mind. The Air Force is taking the lead in the B–70 program.

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. In your opinion, would it be proper for the Air Force to take the lead in the development of a supersonic transport, or would it be better for NASA to take the lead?

Mr. JOHNSON. We would have no objection to the Air Force taking the lead or any other Government agency taking the lead. The FAA should have a part in whatever—at least an opportunity to present the views of the commercial people. A somewhat parallel situation which may be of interest to the committee has developed in connection with the new cargo airplane which the Air Force has in the current budget; a $50 million amount, I believe, has been appropriated by the House to develop a new cargo airplane. In this case the military took into consideration the views of the commercial people through the FAA and out of this consideration tried to evolve an airplane that would meet both military and commercial use.

The CHAIRMAN. Is the military taking the lead in setting down the requirements?

Mr. JOHNSON. Yes, sir; the military is the responsible body. I was trying to point out, I guess, that this cooperative effort of views as between military and commercial has some precedents for it. The reverse of this, of course, could also take place, I am sure.

The CHAIRMAN. You are not interested in who takes the lead governmentally, but rather in filling the place so that somebody has the lead?

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. You are not playing favorites, one branch over the other?

Mr. JOHNSON. We believe both commercial and military interests should be taken into account in the design of such an airplane.

The CHAIRMAN. What do you think this program will cost, assuming the B–70 program contributes around 80 percent of the costs of research and development of the transport?

Mr. JOHNSON. I think we need to clarify our terms, Mr. Chairman. The B–70 just as General White said, and as previous witnesses have said, is an extremely important project to the supersonic transport, but its main contribution to a commercial transport would be in the research and development side of the project and certainly without this contribution the costs that we might talk about would be much greater than they otherwise would be.

But, when you get to the point of laying down a commercial airplane, it will likely be somewhat different than the B–70 itself. It might be quite a different size, for example.

The CHAIRMAN. The engines ought to be about the same?

Mr. JOHNSON. Yes, sir; the engine part of it would be a very fine contribution to the development, and all of the research phases, such as the testing of new kinds of metals for the use in the planes at that speed, and operating various kinds of systems at both the speeds and altitudes will be extremely important.

The CHAIRMAN. The basic metal would be the same. The stress and strain on those metals would be all worked out by the military in advance through the B–70?

Mr. JOHNSON. Yes, and an important contribution.

The CHAIRMAN. The configuration of the aircraft would be somewhat different, more seats, a different interior, and the fixtures would be different, of course.

Mr. JOHNSON. The fact of the configuration, the size, for example, being probably different would in itself cause some problems in money. I guess after we take into account what the very wonderful contributions are the B–70 would make, we would still feel the development cost of a commercial airplane would be at least $250 million additional.

The CHAIRMAN. Taking advantage of all the experience of the B–70?

Mr. JOHNSON. Yes, sir. There are a number of places where there would be important differences which in turn would lead you to a situation that doesn't meet the eye, having to do with tooling. Your tooling therefore would, of course, be different.

The CHAIRMAN. Your gadgetry would be similar.

Mr. JOHNSON. Yes, sir. Without the B–70 this cost I speak of would be probably doubled at least as a guess.

The CHAIRMAN. Mr. Riehlman.

Mr. RIEHLMAN. I have no questions.

The CHAIRMAN. Mr. King?

Mr. KING. Nothing.

The CHAIRMAN. Mr. Morris?

Mr. MORRIS. No questions, Mr. Chairman.

The CHAIRMAN. May I ask one or two more, and then we will be able to finish by noon without any trouble.

Summing up what you have had to say, you urge that we proceed with the program with utmost speed then?

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. You have represented in your statement very graphically what would happen if we were second in the development of this trisonic jet transport. We would lose prestige, our leadership in aviation, and we would lose the commercial advantage that we would gain by being able to sell these planes to other nations?

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. Not being able to sell our planes, foreign countries would make inroads not only in our own foreign markets, but local markets too.

Mr. JOHNSON. Exactly.

The CHAIRMAN. So that we would lose a great deal financially, too?

Mr. JOHNSON. Yes, sir.

The CHAIRMAN. I have no further questions.

If there are no further questions by members of the committee, I shall thank you very much for coming here and presenting a very fine statement. We appreciate it very much.

If there is no further business, the subcommittee will stand adjourned subject to the call of the Chair.

(Whereupon, at 11:45 a.m., the subcommittee was adjourned, to reconvene at the call of the Chair.)

APPENDIX

CONTINENTAL AIR LINES, INC.,
Denver, Colo., May 5, 1960.

Hon. OVERTON BROOKS,
Chairman, House Science and Astronautics Committee,
House of Representatives, Washington, D.C.

DEAR MR. BROOKS: My sincere compliments on your foresight in calling public hearings to gather information on the forthcoming supersonic transport.

As you may know, Continental Air Lines for the past year has had a special team evaluating supersonic transports, for we're convinced that such 2,000-mile-per-hour aircraft will enter scheduled airlines service between 1965 and 1970, with 1967 the probable year.

The plane, we believe, will be in the mach 3 to mach 3.5 class (the limit of our present jet engines), and weigh no more than a present subsonic jet (250,000 pounds) and be able to carry 80 passengers from coast to coast in 1½ hours or halfway around the world in 6 hours.

Financing the initial prototype, of course, is the biggest stumbling block to production of a supersonic passenger transport. However, the problem is not insurmountable because of the vast sums already expended by the Federal Government in development of air frames and engines for supersonic military planes now flying or in the design stage. Because of these expenditures already made, I believe that only an additional $75 to $100 million would be needed for the prototype, rather than the vast sums some people are quoting; yet, even this amount would be too great for either our manufacturers or our airlines to finance.

I believe there is a simple solution to the problem, and one that could not be classed as subsidy. If the Federal Government financed the prototype, then was repaid through royalties on all production aircraft, the end result would be to give this country supersonic transports far earlier than they would otherwise be available, and at no net cost to the taxpayer.

The British Government financed the Vickers Viscount in the same way with royalties more than repaying the initial expenditure.

It's obvious that foreign governments, particularly the Russians, will be behind development and production of their own supersonic transports. Since the world market may be no higher than 150 to 200 such transports, only one model may be built world wide. If a foreign manufacturer produces that model, U.S. airlines may have to buy it to maintain their competitive position, seriously injuring our own aircraft manufacturers.

Rest assured that other nations will do everything in their power to be first with a supersonic transport, not only for prestige, but for the chance to dominate world markets.

I sincerely feel that this country cannot afford to let that happen. We cannot afford to be second with a supersonic transport, for in this race there may be no second place.

Very truly yours,

ROBERT F. SIX.

DENVER, COLORADO, *May 13, 1960.*

Mr. CHARLES F. DUCANDER,
Executive Director and Chief Counsel,
Committee on Science and Astronautics,
House of Representatives,
Washington, D.C.

DEAR MR. DUCANDER: Mr. Robert F. Six, president of Continental Air Lines, asked me to forward background material covering the operational phases of the supersonic transport to supplement the material he already has forwarded

to the Honorable Overton Brooks on the economic and national prestige aspects of such a plane.

The changes we will face in operating supersonic transport airplanes are not expected to be of such a magnitude as to delay in any way the introduction of the SST. Although the increase in speed will be of the order of four times, changes in other considerations will not be as great as those recently encountered in the introduction of the subsonic jet transport. In fact, the successful transition from piston-propeller to pure jet airplanes gives us confidence that proper planning will make possible a successful next step to the SST.

Our preliminary analysis of operating problems that we expect to encounter with an SST of the size and speed as described in the attached SST fact sheet is as follows:

1. Takeoff.—The mach 3 SST will have takeoff performance at least equivalent to present subsonic jets. This means that present airports can be used. An 80-passenger mach 3 transport weighing 250,000 pounds would have thrust in four engines totaling 100,000 pounds. Present subsonic 707–100 series jets have 54,000 pounds of thrust for the same weight. This higher thrust to weight ratio more than compensates for the supersonic wing design which will produce less lift at lower takeoff speeds.

2. *Noise.*—Supersonic transport engines will make more noise than present subsonic transport engines. The higher noise level will be confined to the airport boundaries, however, since the SST will climb at a much steeper angle than the subsonic transport. At any point outside the airport boundaries there will be less noise reaching the ground from a departing SST than from a subsonic transport. In the climb, speeds will be below the speed of sound until reaching at least 35,000 feet. At this altitude sonic pressure waves reaching the earth will be attenuated by the 35,000 feet of air and the angle of climb so that there will not be a loud, sharp crack, as experienced when an airplane creates a sonic wave while diving, but a low, rumbling sound which will be similar to distant thunder. At mach 3 cruise speeds at 70,000–80,000 feet, sonic pressure wave noise on the ground will not be objectionable. The theory of predicting noise levels which will be encountered with the SST has been verified by a NASA research project.

3. Navigation.—Navigation accuracy will be more important on the SST than on current jet airplanes. Small angles of error in flight direction will produce large deviations from course in short periods of time. Combinations of navigation systems, such as Doppler radar and inertial, electronic computers to compute flight path error corrections, and autopilots will be necessary to fly economical flight paths. All these systems are well along in development and testing and will be available for the SST.

4. Approach and landing.—Approach and landing techniques will be very much the same as those presently used for subsonic jet transports. Descent will be made at subsonic speeds to preclude sonic pressure wave noise on the ground and to limit the rate of descent so that the cabin pressure can be raised at a tolerable rate. Approach and landing speeds will be no higher than present subsonic transport speeds.

5. Traffic control and flight planning.—Flight planning for the SST must be more precise than that for the subsonic transport. To plan a flight when flight time and fuel required are subject to wide variations depending on assigned altitude and route, is the most difficult operational problem we will face. This problem can only be solved by a vastly improved traffic control system. The traffic control system must provide a clearance including takeoff, route and altitude, approach, and landing which will reserve the airspace and airport runways for each of these phases of flight at the specific time required. The reserved airspace for the flight cannot be changed once the flight is airborne. Visual collision avoidance cannot be relied upon at mach 3 speeds, so a continuous ground radar surveillance of the airway will be required. The electronic data processing equipment and radar required to provide the needed traffic control is available, although it is not installed at FAA facilities at this time. Present programs to install such equipment, if pursued with the idea that they are absolutely essential for SST operation, will provide adequate traffic control by the time the SST's are operational. The monitoring of each SST flight must be continuous so that any changes in weather or airport conditions can be immediately evaluated and any diversions implemented in a few minutes so that the airplane can most efficiently reach an alternate airport.

6. Ground handling.—Present general techniques for subsonic jets would apply with more emphasis on minimizing ground time. Unproductive time for a mach 3 transport will be four times as costly as for subsonic jets. All methods for expediting fueling, servicing and passenger loading will be employed.

We'll be happy to forward any additional material which you need.

Sincerely,

JAMES E. COLBURN,
Director, Flight Engineering and Technical Procedures.

SUPERSONIC TRANSPORT FACT SHEET

Date of introduction: 1965–70 with 1967 the probable year.

Basic materials: Stainless steel and titanium.

Cruising speed: Mach 3.0 or approximately 1,980 miles per hour. San Francisco to Hawaii: 1 hour, 40 minutes; Chicago to Hawaii: 2 hours, 35 minutes; coast to coast, 1 hour, 45 minutes; no nation more than 6 hours away from U.S.

Cruising altitude: 60 to 80,000 feet.

Propulsion: Nonafterburner turbojets with 25,000 to 30,000 pounds of thrust.

Fuel: JP type fuel.

Airport requirements: Same as for subsonic jets.

Seating capacity: 80 first class. No windows. Flat plate television for passengers to view ground or atmosphere.

Takeoff gross weight: 204,000 pounds San Francisco to Honolulu, including 71,000 pounds of fuel. 250,000 pounds Chicago to Honolulu or approximately same weight as Boeing 707–124.

Cost of production models: Approximately $13 million each, based on production order of 75 to 100, or less than three times cost of Boeing 707 or less than 7 times price of DC–7.

Productivity of each SST: Four times Boeing 707, 12 times DC–7.

Financing: Continental, with current assets of approximately $80 million, would need only two SST's or a total investment of less than $30 million including ground equipment to serve Hawaii.

Utilization: Continental could operate 35 round trips per week between Hawaii and the mainland with 2 aircraft (10 San Francisco to Honolulu, 20 Los Angeles to Honolulu, 5 Chicago to Honolulu).

Operating costs: Per flying hour: $1,700 San Francisco or Los Angeles to Honolulu; $1,800 Chicago to Honolulu.

Total cost per seat mile: San Francisco or Los Angeles to Honolulu 2.62 cents (1.47 cents direct; 1.15 cents indirect) Chicago to Honolulu 2.47 cents (1.32 cents direct; 1.15 cents indirect).

Development cost of SST: $75 million to $100 million for a prototype. Low cost because of Government aid to date in engine development and production of military supersonic planes.

World market: 150 to 200 SST's.

Role of SST: Supersonic transports would supplement, not replace present subsonic jets. SST's would be used for long-range first-class service. Present subsonic aircraft would become coach aircraft for long-range routes. Development of an SST would give U.S. a prestige transport.

AMERICAN AIRLINES,
New York, N.Y., May 6, 1960.

Mr. CHARLES F. DUCANDER,
Executive Director, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. DUCANDER: I acknowledge your letter of May 4, about supersonic air transportation.

I made a talk on this subject, Aviation Writers Association, Los Angeles, May 2, and I enclose a copy of the remarks made there. These reflect my views on the subject.

If I can be of further aid will you let me know?

Sincerely yours,

C. R. SMITH.

SHOULD WE BUILD A SUPERSONIC TRANSPORT?

No supersonic, passenger-carrying transport has been designed or built. None, to the best of our knowledge, is now underway. Newspaper stories indicate that the British may be considering the authorization of a supersonic transport pro-

gram. There are rumors that the Russians also have this in mind. These stories and rumors may have some foundation of fact but neither have been confirmed.

A project of this magnitude and complexity must, of course, be approached with suitable caution. It will be quite difficult, and very expensive, to bring about a mach 3 transport. In addition to the usual reasons for caution, we have a tendency to be satisfied with what we have, to conclude that speeds of 600 miles an hour are sufficient for the time being, and to postpone the time of decision because the decision is difficult.

To build or not to build a supersonic transport involves, of course, an economic decision of the highest order. In addition, there are military implications that must have attention. On top of all of this, there are world political factors, the evaluation of which may tax the ability of our statesmen.

The United States is the world leader in aviation. It may be of great importance, in the kind of world in which we live, to be sure that we maintain that position. Whether we can continue to be the leader, if we are not willing to lead in the introduction of supersonic air transportation, remains to be decided.

The building of a supersonic transport will cost a lot of money. We should make no decision until all of the pertinent facts are in hand. But we should be diligent in accumulating these facts and in weighing their significance. There are already too many areas for which the United States has no national policy, and this should not be another.

WHAT CAN A SUPERSONIC TRANSPORT DO?

Our best source of knowledge about the potential performance of a supersonic airliner is the specification for the B–70 bomber:

The B–70 is designed to cruise at 2,000 miles per hour and to fly nonstop for 7,000 miles. It can operate at 80,000 feet and at that altitude it should do 33 miles per minute. Using existing B–52 bases, the B–70 could reach any part of the world in 6 hours. Most of its potential targets could be reached in 2½ hours. For a flight of that distance the B–70 should have a payload of 20 tons.

A supersonic airliner might be a bit slower, because its fuselage would be larger, but the mach 3 transport should be able to go from New York to Paris or London in about 2 hours. If the B–70 can carry 40,000 pounds for a journey of 2½ hours, the transport would certainly do no less for a shorter journey. A 20-ton payload should permit the transportation of 200 passengers, or a smaller number with residual capacity for mail and cargo.

WILL THE B–70 BE BUILT?

Whether or not the B–70 program will go forwarded will be decided by the Congress. The position of the Air Force is, I believe, that military necessity dictates the completion of the program. As of now, a single prototype is authorized. Whether or not there will be additional planes will depend on the decision of the Congress, hinging on a decision about the appropriation of necessary funds.

RELATIONSHIP BETWEEN THE B–70 PROGRAM AND THE SUPERSONIC AIRLINER

Jet air transportation (subsonic) came into service earlier than most of us would have been willing to predict some years before. The reasons for the earlier availability of the jet transport were these:

1. The development of high-speed, long-range bombers, with great carrying capacity: This development advanced the state of the art; their design, construction, testing, and operation brought along know-how, experience, and confidence;

2. The financial courage of the airplane manufacturers: They risked very large amounts of capital, with heavy losses to date;

3. The financial courage of the airlines: They were willing to modernize their fleets, involving the retirement (at substantial loss) of the fleet in being. They risked their capital and, in addition, borrowed hundreds of millions of dollars, to finance their purchase of jet aircraft.

There was and is no direct relationship between the development of military bombers and the later development of jet airliners. The contribution made by the military department was the advancement of the state of the art.

Some examples:

Airframe design: The bomber had to have a "clean" profile and high-speed characteristics. Some of this could come from better aerodynamic design, some of it from higher thrust engines. Most of the discoveries in better aerodynamic efficiency could later be translated into advantage for the civilian airliner;

Powerplants: Necessary speeds could not be developed with the jet engines earlier available. Higher thrust had to be developed. Better engines were developed and these were later available for the civilian airliner;

Fuel economy: This, of course, was a part of the engine development program, and an important part. Existing engines were powerful but their fuel consumption was excessive. The bombers needed long-range ability, to complete their mission and get back home. Excessive fuel consumption, obviously, reduced the range. More efficient engines were developed, providing the range required. These same engines, or their civilian counterparts, later powered the jet airliners, and gave them the ability to cross the oceans nonstop.

The development of existing types of bombers brought about an advancement of the art, and advancement sufficient to make possible the development of subsonic air transportation. But to go from 600 miles per hour to 2,000 miles per hour will require another advancement of the art. Some of the necessary knowledge has come from the development of the B–58 bomber, capable of supersonic speed, but speed well below 2,000 miles per hour. The development of the B–70 is the first attempt to give a large airplane a speed potential of mach 3 (three times the speed of sound). This is entry into what has heretofore been an unproven area of aerodynamic advancement.

A mach 3 transport will not be built until the ability to operate at mach 3 has been proven. That, of course, could be done by starting such a transport from "scratch." The more usual way, and the better way, would be to develop a mach 3 military machine first. The best opportunity to do that lies in the completion of the B–70 program.

HIGH CAPITAL COST

The very high capital cost for a mach 3 development program places that project beyond the ability of the privately owned airplane manufacturer; he just does not have that much capital and he cannot afford to take so large an economic risk.

If a mach 3 airplane should be built in England, it would have to be sponsored and supported by the British Government. If it should be built in Russia it would, of course, be a direct responsibility of the Russian Government. If it is to be built in the United States, then the United States must be behind the project.

HERE ARE SOME OF THE FACTORS WE NEED TO EVALUATE

1. The experience to date with the B–58 and the B–70 design projects demonstrates, we believe, that a supersonic transport is technically feasible;
2. If that be proven, the size of the stakes will encourage some nation to build a supersonic airliner;
3. Leadership in the introduction of supersonic air transportation will bring great prestige to the nation first in the field;
4. If some other nation should gain leadership in aviation by the pioneering of supersonic air transportation, the United States would be required to "catch up";
5. It is probable that it would cost no more to be the leader in the introduction of supersonic air transportation than to "catch up" at some later date. (It probably would cost less to lead, provided the technical solutions are produced in the B–70 program).

COMMERCIAL AND FOREIGN TRADE IMPLICATIONS

Assuming that the operation of the supersonic transport should prove to be economic (i.e., have the ability to produce and sell air transportation at a price the customer would pay), the use of the supersonic transport would revolutionize the transportation services of the world. The airlines of that nation might dominate the air routes of the world. The factories of that nation would have a saleable product for export.

NATIONAL PRESTIGE

Two world ideologies seek to attract followers. We represent one of these ideologies.

Publicity and prestige are important factors in the attraction of followers. It is the objective of each to portray itself as being strong, competent, and progressive, and to portray its opponent as being weak, incapable, and vacillating. In conveying these impressions to others, both of the ideologies use, and need to use, expensive and spectacular apparatus, often allied with scientific undertakings.

The launching of sputnik made a vivid and lasting impression on world opinion. It created world prestige for the Soviet Union. Sputnik, without doubt, made a contribution to the broadening of knowledge. Even if it had made no contribution, the cost of sputnik could have been justified by the Russians on the basis of its propaganda value.

The pioneering of supersonic air transportation, being first to have the ability to go halfway around the world in 6 hours, will have great propaganda and prestige value. It should be remembered that the "new" has been worn off the launching of satellites. Better propaganda opportunity may be found in other areas. Supersonic air transportation may be one of these.

CONCLUSIONS

1. It is likely that a supersonic transport will be designed and built by some nation;
2. The building of a supersonic transport may have a decisive effect on world leadership in aviation;
3. The building of a supersonic transport is not, at this state of development, a "business" decision. The decision cannot be made by the airplane manufacturers, or by the airlines, or by both. The cost of the project is too much for their capital resources;
4. If a supersonic transport is soon to be built in the United States it will have to be justified and authorized on the basis of the national interest and the project will have to be sponsored by the Federal Government;
5. The implications of world leadership in aviation (the prevention of the loss of that position), with its potential effect on all of our foreign relations, makes it essential that the Government face this issue and come to some decision about it. Nothing is to be gained by continuing to drift.

PRATT & WHITNEY AIRCRAFT,
DIVISION OF UNITED AIRCRAFT CORP.,
Hartford, Conn., May 12, 1960.

MR. CHARLES F. DUCANDER,
Executive Director and Chief Counsel,
Committee on Science and Astronautics,
House of Representatives,
Washington, D.C.

DEAR MR. DUCANDER: We appreciate very much your invitation to express our views on supersonic jet transport aircraft development to the U.S. House of Representatives Committee on Science and Astronautics.

Pratt & Whitney Aircraft's extensive research and development programs have resulted in the ability to supply a number of current production engine models capable of operation at high mach numbers. For example, although its actual mach number is classified, the J–52 engine used in the Hound Dog missile is capable of operation at high supersonic speeds, the widely used J–57 engine has considerable time at mach 2, and the J–75 series engine used in the successful F–106 speed record attempt was operated at mach 2.4. We have expended a great deal of effort over a number of years not only to reach these speeds but to develop the capability of still higher supersonic sustained operation. This work has resulted in the development, under Navy sponsorship, of the JT–11 (J–58) engine which has already been experimentally operated at mach 3 in our altitude test facility. In addition, we have maintained a close working relationship with the major aircraft companies on the preliminary design of still further advanced powerplants which might be developed for both military and commercial supersonic aircraft.

Against this background we would like to submit our thoughts for the committee's consideration.

Research and development.—The single most important technical decision which must be made is whether the supersonic transport should be designed for approximately mach 2 or for mach 3. As indicated in paragraph 2, relatively complete technical information is available for a mach 2 design. The problems, while difficult, are relatively well defined. A mach 3 design, however, would require an extension of the aerodynamic and structural art considerably beyond existing proven experience. The development cost of a mach 3 aircraft probably would be several times that of a mach 2 aircraft. If the basic reason for proceeding with development of a mach 3 transport is national prestige, then the results may justify the large increase of additional effort and expense.

Based on actual full-scale operating experience under simulated conditions up to mach 3, we are confident that a suitable powerplant can be developed for a supersonic transport aircraft within a required time period, that is, a lead-time allowing for an orderly pace through intensive research, exhaustive experimentation and thorough development. The JT–11 (J–58) jet engine, now under development, could be available in advance of a supersonic transport aircraft initiated at this time.

Financial feasibility.—Most of the supersonic transport studies conclude that the seat-mile operating cost may be comparable to that of current subsonic jet aircraft if development costs are considered separately. It is clear that the development cost of a supersonic aircraft will be of such size that it will need Government support.

Operating potentials.—The number of aircraft needed would depend of course on the route structures, but the number probably would be small compared to the subsonic jet plane fleet. The aircraft would be designed for nonstop transcontinental and transoceanic ranges to reap increased speed advantage. Greater schedule frequencies and sharp reduction in travel time, however, would open new markets among a steadily expanding world air-travel population. Cargo possibilities also would be tremendous.

It is our belief that the introduction of a supersonic transport by the civil airlines must necessarily be a careful process. It does not appear at the moment that there will be extensive use of high supersonic aircraft within the military to build up a background of operating experience prior to introduction of supersonic transports. The lack of such valuable background will demand comprehensive development programs with a concentration on endurance testing under simulated flight conditions. It may take several years after the initial flight of the prototype model to achieve commercial safety and reliability standards.

Noise problems.—Airport and in-flight noise problems naturally will require serious study. Powerplant noise stems from the thrust output and hence will vary with the size of the aircraft and its thrust requirements. The thrust available in transonic acceleration, however, will give high performance during climb outs so that the perceived neighborhood noise level should not be too severe. This, of course, will depend on allowable departure procedures and climb paths. Sonic overpressure can result in serious noise problems, but available data indicates that these effects can be alleviated by delaying acceleration to supersonic speeds until a relatively high altitude is reached. From the standpoint of the powerplant, this demands an engine capable of good subsonic climb performance in addition to satisfactory supersonic cruise capability.

National prestige.—In our opinion, the U.S. commanding position in civilian and military aircraft production would suffer if other countries were the first in supersonic transport development. Several times, in a single generation, the Nation has experienced dangerous periods because of the absence of a sustained, forward-working aircraft development program. The same has been true in the case of the decline of American shipbuilding and the mercantile marine program.

For some time there have been press reports to the effect that the British Government is considering the building of a supersonic transport. Without disclosing details, Duncan Sandys, the British Minister of Aviation, in a statement last February promised a support program for the British aviation industry which included (1) the development and tooling costs for selected civil aircraft and engine projects, (2) proving and other costs involved in introducing new aircraft into service, (3) working capital to back speculative production targets, and (4) general aeronautical research and development work. Sandys is quoted at the time as saying that the support the Government is offering

would enable the aircraft industry to assume greater risks. Reports from France indicate that the French Government also is considering a supersonic transport program and it is probable that the U.S.S.R. is devoting some effort on a supersonic transport.

The technological initiative represented by the development, production and operation of supersonic transports will enhance the prestige of the country accomplishing it, and give its aircraft and airline industry a marked advantage in world trade.

The U.S. aircraft industry has a stake in foreign trade. This is economically important, aside from the prestige of having American civil aircraft purchased abroad as well as at home. Foreign sales are a source of revenue the industry would like to retain, a source of employment for scores of thousands of U.S. workers in the aircraft and related industries. The Aerospace Industries Association of America has reported that in 1959 the U.S. aircraft industry exported a total of $769,400,000 worth of products. In 1956 the exports amounted to $1,059,300,000.

In summary, we believe that it may be of great importance to our national prestige to develop a supersonic transport aircraft. The technical knowledge exists to construct a practical supersonic transport, but the magnitude of the development is beyond the financial capabilities of private industry.

Most of the critical problems have been recognized and many are well along toward resolution. Pratt & Whitney Aircraft has demonstrated the feasibility of operating turbojet engines at the temperature and pressure conditions of high supersonic flight speeds and has in existence the facilities to carry on this development.

We think it highly important that a decision be made to proceed with the development of a supersonic transport so that the United States does not lose the present technical advantage it now enjoys in the field of high-performance civil aircraft.

We thank you for this opportunity to express our views on this important subject.

Respectfully yours,

L. C. MALLET, *General Manager.*

DOUGLAS AIRCRAFT CO., INC.,
Santa Monica, Calif., May 13, 1960.

Mr. CHARLES F. DUCANDER,
Executive Director,
Committee on Science and Astronautics,
House of Representatives,
Washington, D.C.

DEAR MR. DUCANDER: This responds to your letter of May 4 informing us of the hearings on supersonic jet transport development and inviting us to submit material for the prospective report of the House Committee on Science and Astronautics.

We are pleased that the committee is directing its attention to this subject, which we consider of great importance to our country. We regret that time apparently will not permit an exhaustive exploration during the present session, particularly since this subject is a highly complex one. However, we understand how burdened the members of the committee are.

It would be our preference to appear before the committee with a fairly extensive prepared presentation and then answer as best we might such questions as the committee and its staff might wish to ask. However, we are pleased to enclose herewith a brief summary of our general approach to the question of a supersonic commercial transport, which we hope may contribute to the immediate work of the committtee.

We are ready as always to assist the committee further in any way that we can if you so desire.

Sincerely,

DONALD W. DOUGLAS, Jr., *President.*

EVOLVING THE SUPERSONIC TRANSPORT—A STATEMENT FROM THE DOUGLAS AIRCRAFT CO., INC.

History teaches that the development of new commercial transport aircraft is an evolutionary process. This has been true both technologically and from the standpoint of the airlines' economic readiness to introduce new types into

service. It is also historically true that, soon after the introduction of a new type, both producers and users have begun to focus serious attention on the next step in the steady progression of improved transport aircraft.

It is therefore proper and logical that, even as high subsonic jet airliners go into widespread service, an acceleration of study on supersonic transports should take place.

We should not make the mistake of believing that the supersonic transport is the ultimate. The process of evolution does not stop. Even as we can today foretell a supersonic transport that will make it possible to leave New York, do a day's business in Paris, and return in the same day, so one can visualize the possibility of rocket transport that would compress still further the time required for transocean or transcontinental travel.

But the evolutions of the future, like those behind us, will occur only as the result of careful, tedious and time-consuming planning, study, and experimentation. There is no such thing as quick-and-easy development of new transport aircraft; to ignore this truism is to court disaster.

Thus, while no basic technological barriers stand between us and the attainment of the supersonic transport, considerable refinement of the state-of-the-art must be accomplished if we are to achieve satisfactory levels of passenger safety and comfort, operational reliability and economy, and completely effective flight management and traffic control systems. We must remember, too, that while progress in the development of commercial aircraft may at times parallel that on military types, there is necessarily a substantial difference between the two. Experience on the one can, and often does, contribute importantly to the other; but, clearly, a B–29 is quite different from a DC–6, and the commercial supersonic transport will be quite different from a B–70 type.

Under our American system of free enterprise the evolution to new types must be supported by sensible economics. The airlines order new aircraft only when they are confident that profitable operations are feasible. With respect to a supersonic airliner, it seems reasonable that the airlines will not only require such a craft to have direct operating costs, per seat-mile, comparable to those of today, but will be influenced in the timing of their orders for such new types by the progress made in assimilating, financially, the jetliners now entering service.

It is not the purpose here to deal in detail with the manifold aspects of supersonic transport development. However, it may serve the committee to mention briefly the major alternative technological approaches, and to essay tentative answers to some of the general questions posed by the committee's chief counsel.

It is possible, employing aluminum construction and well-tried fabrication techniques, to develop a transport that will cruise at speeds up to about Mach 2.3. For greater speeds, however, because of high temperatures, another material—some alloy of steel—becomes necessary. Such an aircraft has been discussed in terms of mach 3 or mach 3.5, but it may prove almost equally feasible to design it for mach 5 or mach 6. The question propounded, and to which no absolute answer may yet be offered confidently, is whether it is wiser to move ahead in perhaps two steps, or to strike at once toward the higher reaches of supersonic flight.

Additional questions relating to supersonic transport developments require study, though answers as they are apparent to us today may be offered:

Runways: The supersonic transport will in all likelihood operate from runways suitable for today's large jet transports.

Aircraft sound: The external sound effects of a supersonic airliner will likely be somewhat greater than those of today's jets, but an ability to climb more rapidly should counterbalance this so that the effect on communities may be no greater than at present.

Sonic boom: The supersonic transport will create a sonic boom, but at cruising altitudes of over 70,000 feet this will be dissipated to a degree minimizing ground effects. Climb to altitude, and let-down to landing, will be at subsonic speeds. Because of sonic effects, however, it may be necessary to establish altitude over terrain, rather than altitude above sea level.

The development in this country of a supersonic transport for global commercial operation should be of great concern to our governmental leaders. Quite apart from any other considerations, it seems clear that an important question of national prestige may be involved here. In both France and the United Kingdom there are serious stirrings in the direction of supersonic transport development, and it would be folly to assume that the Soviet Union is not pressing forward in the same direction.

For these reasons, and because the magnitude of the development task appears well beyond the immediate financial capabilities of any one American aircraft company, some Government assistance program that does not basically violate free enterprise concepts deserves consideration. We have given thought to this question and believe that, operating through the Federal Aviation Agency, our Government might consider an approach along the following lines:

1. Establish a study program with those companies who have the capability for eventual production (there are about five). The object would be for each to develop a concept and a plan for achieving operational supersonic transports to meet the commercial airline requirements. (An in-house FAA program to crystallize these requirements would also be desirable.) It is estimated that 9 months to a year would be sufficient for this effort at a cost of approximately $1 million per contractor. Multiple as well as single source should be considered to provide full opportunity for team effort if it appears to be desirable.

2. Based on the evaluation of the proposals resulting from these studies, award research and development contracts to advance the state of the art as required. This phase of activity may extend through 1965 and would require between 10 and 15 million dollars per year. Concurrent NASA work is assumed. It is also probable that some engine development to achieve commercial characteristics will be necessary.

3. Preliminary design can be started by 1962 or 1963, preferably with one contractor or one contracting team unless state of the art advances recommend investigation of alternates. Production engineering, manufacturing, and flight testing will follow with operational aircraft becoming available in the late sixties. By comparison with military programs this may seem to be a larger development period than necessary. In our opinion, the time required to advance the state of the art to the required commercial levels of safety, reliability, and economy may easily be this long or even longer. Equally important is the time required for the commercial market to develop capital to purchase and the demand to sustain transports with supersonic capability. Again, in our opinion, it will be the late sixties at least before this level of economic plausibility will be achieved.

Total costs for the development of a commercial supersonic transport are estimated in excess of $500 million and might well approach a billion dollars. It is our hope and belief that even this gigantic enterprise can be carried out without resort to any scheme inimical to our free enterprise system. Government assistance but not complete subsidization should be the objective. The possibility of at least partial repayment of government research and development assistance through subsequent commercial sales deserves study. Moreover, since both the technological and operational support relationship between military and commercial aircraft are complementary, it is not too much to say that the national security could well benefit through Government assistance in the development of a commercial supersonic transport.

REPUBLIC AVIATION CORP.,
OFFICE OF THE PRESIDENT,
Farmingdale, Long Island, N.Y., May 17, 1960.

Mr. CHARLES F. DUCANDER, *Executive Director and Chief Counsel*
Committee on Science and Astronautics
House of Representatives, Washington, D.C.

DEAR MR. DUCANDER: Republic Aviation Corp. is pleased to submit to the Committee on Science and Astronautics some observations and recommendations on the subject of a supersonic jet transport. Although most of our company's efforts have been devoted to producing fighting machines we have always had a keen interest in the field of fast transportation. Fifteen years ago we designed a four engine transport, the *Rainbow*. This aircraft was the commercial version of the Air Force R–12 high speed reconnaissance airplane, of which two were built and flown.

The design of this airplane was based on the military experience gathered during World War II. The *Rainbow* achieved remarkable performance for that time; with reciprocating engines and propellers it reached a high speed of nearly 500 miles per hour, and a cruising speed of over 400 miles per hour at an altitude of 40,000 feet. It had a range of 4,000 statute miles. This performance was not equaled or surpassed until the latest jet transports entered the field. Unfortunately, financial problems in the industry in 1946–47 prevented us from going into production with this aircraft.

It has always been a source of great disappointment to us that the *Rainbow* did not enter commercial service, for surely the entire history of commercial transportation over the past 10 years might have taken on a different pattern. The force of competition to better the *Rainbow* might have caused the development of jet transports sooner, and we might now be closer to supersonic transports than we are.

Because of our long standing interest in high speed transportation, Republic has engaged in recent studies in the area of economical supersonic transportation. To achieve good economy the supersonic transport will require a long range and high payload capability, and since the development cost will also be high it should probably also be useful to the military organizations as a logistic carrier. We have estimated a development cost, including three prototype vehicles, of about $300 million. This does not include the cost of developing a new engine should it prove desirable. It assumes instead that use will be made of one of the engines currently available or being developed for military use.

Most of our studies have centered around supersonic military logistic carriers, but nearly all of our conclusions apply to the commercial carrier as well. The aircraft should have the following characteristics:

1. A range of about 3,500 nautical miles.
2. A cruising speed corresponding at least to a mach number of 2 and probably over 3.
3. The aircraft must be able to use existing runways lengths and allowable tire pressures.
4. It should be economically competitive with the present day jet airliners.

An aircraft of this type could be available by about 1965, but the airlines may not be ready for it until about 1970. The military could use the airplane almost immediately.

Of course, there are many problems which must be investigated and overcome. Our economic studies indicate the desirability for a large airplane, possibly 500,000 pounds. However, this introduces many complications. Among these are the following:

1. A large airplane implies a small fleet. Such aircraft may be difficult to fit into any one airline's schedules efficiently.
2. In a small fleet each individual aircraft takes on greater importance. Equipment trouble ties up a greater percentage of a fleet, and a crash would involve a larger number of passengers.
3. The ground shock problem is almost directly proportional to the weight of the aircraft. We are already beginning to encounter difficulties with mach number 2 aircraft flying at high altitudes and weighing only about 150,000 pounds.
4. Large aircraft mean high total power, and the noise problem is proportional to the power.
5. Large aircraft will require more engines than the airlines would care to handle, probably six or eight engines per aircraft.

These considerations may force the use of a smaller aircraft, making it difficult to compete with present jet costs.

There are several engines available which could be used for this application. These include Pratt & Whitney's J58 and General Electric's J93, which are already available. Pratt & Whitney's J91 is a larger engine and may be desirable. It could be available with some additional support. A turbofan could be developed for this application and might be best, but this would add to the development cost of the aircraft.

To achieve good fuel efficiency, in addition to an economical engine, the aerodynamic lift to drag ratio is important. Recent NASA tests are encouraging in this area. However, this might involve the use of variable geometry with its resulting reliability and maintenance problems. In addition, if some aerodynamic trick is needed to reduce ground shock, it may prove harmful to the lift-to-drag ratio of the aircraft. Attainment of the high L/D ratio is further restricted by the need for a large fuselage diameter relative to the aircraft size. The need for good takeoff and landing characteristics will dictate a good flap and therefore a tail (probably canard) to balance the flap moment. This also limits the L/D ratio.

Another important area to be considered is the structural material to be used. As speeds go beyond a mach number of 2, structural heating is encountered. Our studies indicate that if a 20,000-hour aircraft lifetime is considered, aluminum alloys could be used up to a mach number of 2. Beyond this point structural weight penalties must be accepted to use aluminum alloys. For instance, for

operating at M=2.3 the temperature of the structure would reach about 260° F. and the weight of aluminum alloy structure would have to be increased by about 15 percent over present-day designs. Beyond this point the penalty rises rapidly. A design using aluminum alloy would therefore preclude any growth potential to higher speeds.

For the higher temperatures encountered at the higher speeds (500° F. at M=3), more exotic materials must be considered. These include heat-treated titanium alloy, using the Deparament of Defense titanium sheet-rolling program developments or hard-worked tool steels such as Vascojet 1000. Using the titanium alloys, actual weight savings over present-day aluminum structure can be obtained, and using the hard-worked steels, present-day structural weights could be maintained. In either case, an energetic development program of honeycomb sandwich materials is assumed.

Since flying altitudes over 50,000 feet will be used, explosive decompression becomes even more important. It may be desirable to eliminate windows in the passenger cabin to improve reliability and save the weight required to incorporate them.

To keep pace with the high flying speeds, there must be a comparable improvement in the ground operations. Our studies show that this can be done by proper design. From a military standpoint the canard tail arrangement lends itself to good cargo handling. It leaves the rear of the fuselage free for a clamshell-type door and ramp, and permits quick, easy loading of self-driven vehicles and large objects through the use of built-in winches. It also makes possible the incorporation of airdrop capability.

The use of such aircraft by the military would lead to obvious advantages. To move an Army reinforced battle group to Dhahran from the United States, for instance, with our best military transports in less than 72 hours, would take about 50 aircraft, and the first landing would take place in about 44 to 48 hours. Using supersonic aircraft, about 20 or 30 would be used, but more important, the first landing would be made in 12 to 15 hours. This saving in time may mean the difference between landing in a hostile environment or a peaceful one.

It is interesting to note that fleet costs are almost independent of speed. Although individual aircraft costs are higher (three to four times present costs), less aircraft are needed. The cost of buying capability of moving 1 billion ton-nautical-miles per year seems to be about $225 million.

Based on our studies, the following conclusions may be reached:

1. A practical supersonic transport could be available by 1965–66.
2. A mach 3 transport has the best potential and even if lower speeds are used at first this capability should be designed into the aircraft.
3. Fleet costs will be comparable to present-day jets.
4. Operating costs can be kept competitive with present jets.
5. Ground handling can be made compatible with the higher air speeds.
6. The use of titanium structure appears desirable and practical.

Sincerely,

MUNDY I. PEALE.

MOTOROLA, INC.,
MILITARY ELECTRONICS DIVISION,
June 14, 1960.

Re Committee hearings:
"Mach 3 Transports; Motorola,
Mission and Traffic Control."

Science and Astronautics Committee,
House of Representatives,
Washington, D.C.

(Attention of Hon. Charles F. Ducander, executive director and chief counsel).

DEAR MR. DUCANDER: Motorola is the developer of the Air Force AN/ASQ–43 mission and traffic control subsystem which provides the electronic communications capability, navigational equipment, and landing aids required for supersonic aircraft. The initial application of this completely harmonious and integrated complement of electronic devices is for the North American B–70 weapon system.

It is Motorola's considered opinion that a supersonic transport will be developed and will appear on the commercial airlines of the world within the next decade. It is essential that such an airplane be of U.S. design and manufac-

ture in continuation of our advancement in technology and worldwide prestige. Going from 600 to 2,000 miles per hour requires several advancements of the art. Aerodynamics and propulsion capability at mach 3 will be proven by the NAA B–70 mission and traffic control capability will be proven by the Motorola AN/ASQ–43.

The time from takeoff to landing for a typical cross-country flight, say Los Angeles to New York, has been shortened in recent years by the advent of higher powered piston aircraft, and even more so with today's turbojet transports. Tomorrow's mach 3 transports will reduce the takeoff to touchdown time to little more than 1 hour. Precise navigation, positive communications, and rigid air traffic control requirements will be imposed upon all such high-performance aircraft. The lack of time for performing all cockpit functions necessary to flight safety requires that controls and displays be simplified, integrated, and automated. The crew simply will not have the time to manually and visually control the necessary comunications, navigation, and landing aid devices.

The design of the mach 3 transport will place a premium on space and weight. The use of many different electromagnetic devices in close proximity in the aircraft requires that the design of the black boxes be of coordinated design engineered to operate as a subsystem of the air vehicle. Only in this way can dangerous radio interferences be eliminated and reliable operation assured.

Development of an airplane which can fly at 2,000 miles per hour is not enough. Development of the electronic devices human engineered and integrated as a subsystem entity necessary for safe takeoff, en route communications and navigation and landing must be coincidental with airframe and propulsion development. Compatability of the airborne equipment with the cooperational ground equipment, the traffic control systems of the next 15 years, and automatic ground checkout equipment must be engineered by the electronic subsystem supplier in concert with the manufacture of the airframe, the airlines, and FAA's long-range requirements. Operating procedures, rules, and regulations, traffic patterns, frequency of operations, schedules, maintenance and turn-around time, etc., are factors affected by the capabilities of the airplane's electronic subsystem.

Motorola's communications capabilities and their forward looking mission and traffic control developments are keeping pace with the progress of mach 3 airframe and propulsion developments. Safe, reliable, and simplified electronics will be available for the 2,000-mile-per-hour transports.

Very truly yours,

QUENTIN G. TURNER,
Assistant General Manager,
Western Military Electronics Center.

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